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Family and individual line selection for palmitate, saturates, linolenate and seed yield of soybean

Leon George Streit
Iowa State University

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Family and individual line selection for palmitate, saturates, linolenate and seed yield of soybean

by

Leon George Streit

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Leon George Streit

has met the dissertation requirements of Iowa State University

Signature was redacted for privacy.

Major Professor

Signature was redacted for privacy.

For the Major Program

Signature was redacted for privacy.

For the Graduate College

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ABSTRACT

Soybean [*Glycine max* (L.) Merr.] genotypes with reduced palmitate, stearate, and linolenate have been developed to improve the nutritional characteristics and oxidative stability of the seed oil. The reduction of palmitate and stearate in soybean is necessary to comply with U.S. Food and Drug Administration (FDA) regulations for vegetable oils that are labeled as being low in saturated fatty acids (U.S. FDA, 1994). The reduction of linolenate should improve the oxidative stability and reduce the formation of undesirable flavor compounds in the oil (Dutton at al., 1951; Smouse, 1979; Mounts et al., 1988; White and Miller, 1988).

Plant-row-yield tests (PRYT) are used by soybean breeders for the initial yield evaluation of experimental lines. The highest yielding lines in the PRYT are advanced for evaluation in replicated tests. The objectives of this study were to compare the family and line methods of selection for reduced palmitate, palmitate + stearate (saturates), linolenate, and for increased seed yield, determine the influence of the combination of reduced palmitate and linolenate on agronomic and seed traits, and determine the effectiveness of selecting lines from unreplicated plots.

Four random F_3-derived lines from 21 F_2 families from each of four populations were evaluated in a PRYT in 1995 and in replicated tests at four locations in 1996. For the family method, the mean palmitate, palmitate + stearate (saturates), linolenate, and seed yield of the four F_3-derived lines of each F_2 family was used to identify families from which to select individual lines. For the line method, lines were selected without regard to the family structure. The fatty ester contents or seed yield of the selected and unselected lines based on data from the PRYT were compared with their mean performance in the 1996 environments. Selection of lines based on data from one 1996 environment was compared with their mean performance in the other three environments. The total number of lines selected by the family method was less than for the line method for all traits in the four populations. The percentage of selected lines that were correctly classified for all traits was similar for both methods. There was a greater percentage of lines incorrectly rejected by the family method than by the line method for all traits. For development of cultivars with reduced palmitate, saturates, and linolenate, and with increased seed yield, breeding methods that rely on family performance

would not be more effective or efficient than methods that ignore family structure. The evaluation of lines in unreplicated plots was useful for identifying lines to advance to replicated tests.

INTRODUCTION

Combining oil quality traits in soybean can improve the nutritional quality of the oil for consumers and increase its value and utilization. A reduction in palmitate and stearate would enhance the nutritional quality by lowering the saturated fatty ester content and a reduction in linolenate would improve the oxidative stability of the oil (Dutton et al., 1951; Smouse, 1979; Mounts et al., 1988; White and Miller, 1988). Soybean genotypes with ≈ 40 g kg^{-1} have been developed by combining the *fap1* and *fap3* alleles for reduced palmitate (Erickson et al., 1988; Fehr et al., 1991a; Schnebly et al., 1994). Genotypes with ≈ 25 g kg^{-1} linolenate were obtained by combining the *fan1*(A5) and *fan2* alleles for reduced linolenate content (Hammond and Fehr, 1983; Fehr and Hammond, 1996). Although there are major genes for reduced palmitate and linolenate, they can be considered quantitative traits due to the influence of environmental effects and modifying genes (Graef et al., 1988; Fehr et al., 1992; Horejsi et al., 1994; Ndzana et al., 1994; Schnebly et al., 1994). Stearate also is considered a quantitative trait and no major genes have been reported for reduction of the fatty ester.

Falconer (1960) suggested that family selection is favored when the heritability of a trait is low and the number of families is large. Selection can be conducted among and within families during inbreeding by the pedigree or early-generation-testing methods (Fehr, 1987). Alternatively, one or more seeds from selected plants can be bulked and selection practiced among lines without regard to family structure by the single-seed-descent and bulk methods. Breeding methods that involve family selection require more record keeping, labor, and land than methods based solely on line selection (Fehr, 1987).

The only comparison of family and line selection for altered fatty ester content in soybean was made by Bravo et al. (1999). They concluded that breeding methods that rely on family performance would not be more efficient or effective than methods that ignore family structure for the development of cultivars with elevated palmitate.

Selection for seed yield is one of the most important and difficult challenges of plant breeding (Voigt and Weber, 1960; Hallauer and Miranda, 1981). Many investigators have compared the early-

generation-testing, pedigree, and single-seed-descent methods to determine the most efficient and effective procedure for soybean product development (Voigt and Weber, 1960; Raeber and Weber, 1953; Empig and Fehr, 1971; Boerma and Cooper, 1975; Luedders et al., 1973; Ivers and Fehr; 1978). Results from these studies have been inconsistent. Wilcox et al. (1984) found that soybean lines with superior agronomic performance tended to come from the families that had a high family mean of individual lines derived from them. Ivers and Fehr (1978) reported the use of the mean of pure lines to identify superior families. They observed that some breeders reselect within superior families. They reported a higher degree of genetic similarity for seed yield among progeny from a F_2 plant. Thorne et al. (1970) indicated substantial gene fixation for yield in the F_2 generation of soybean crosses suggesting that lines with superior performance might not be identified within F_2 families that had a high mean performance.

The initial yield evaluation of soybean lines from segregating soybean populations commonly is done in unreplicated plant-row-yield tests (PRYT). PRYT have been utilized by soybean breeders to identify promising lines before replicated tests are performed (Schillinger, 1985). Hegstad et al. (1999) concluded that PRYT would be useful to identify soybean lines with higher yield potential. Byrum (1999) proposed the use of molecular markers to increase the effectiveness of identifying high-yielding lines from PRYT. He concluded that the use of molecular markers alone or in combination with PRYT would be useful for selecting among lines for seed yield in a cultivar development program.

The objectives of this study were to compare the family and line methods of selection for reduced palmitate, saturates, linolenate, and for increased seed yield, determine the influence of the combination of reduced palmitate and linolenate on agronomic and seed traits, and determine the effectiveness of selecting lines from unreplicated plots.

LITERATURE REVIEW

Fatty Ester Inheritance

Reduced palmitate content in soybeans has been attributed to two major alleles: *fap1* and *fap3* (Fehr et al., 1991a; Schnebly et al., 1994). The *fap1* allele was developed by treating seeds of 'Century' with ethyl methanesulfonate (EMS) (Erickson et al.,1988). The *fap1* allele was identified in a M_2 plant that was designated C1726. The *fap3* allele was developed by treating seeds of 'A1937' with N-nitroso N-methyl urea (NMU) (Fehr et al., 1991a). The *fap3* allele was identified in a M4 plant that was designated A22. The line A18, with the genotype *fap1 fap1 fap3 fap3*, has < 40 g kg^{-1} palmitate and was obtained by crossing A22 (≈ 78 g kg^{-1} palmitate) with C1726 (≈ 85 g kg-1 palmitate). The palmitate content of conventional cultivars is ≈ 110 g kg^{-1} (Fehr et al., 1991a). Although there are major genes for reduced palmitate, it can be considered a quantitative trait due to the influence of environmental effects and modifying genes (Horejsi et al., 1994; Ndzana et al., 1994; Schnebly et al., 1994; Rebetzke et al., 1998).

Reduced linolenate content is attributed to three major alleles developed by chemical mutagenesis: *fan1*, *fan1*(A5) and *fan2*. Wilcox and Cavins (1986) developed the *fan*1 allele by treating Century with EMS. The mutant line was designated C1640, which has a linolenate content of ≈ 35 g kg^{-1} compared with ≈ 70 g kg-1 for Century. The *fan1*(A5) alelle was developed by treating FA9525 with EMS and *fan2* by treating FA47347 with EMS (Hammond and Fehr, 1983; Fehr and Hammond, 1996). The *fan1*(A5) allele in the mutant A5 reduced linolenate to ≈ 34 g kg^{-1}, while the *fan2* allele in the mutant line A23 reduced linolenate to ≈ 56 g kg^{-1} (Fehr et al., 1992). The development of the genotype *fan1*(A5) *fan1*(A5) *fan2 fan2* reduced the linolenate content in soybean oil to ≈ 25 g kg^{-1} compared with ≈ 77 g kg^{-1} for normal cultivars (Fehr et al., 1992). Genetic variability for other fatty esters has been produced by subjecting commercial soybean cultivars to chemical mutagens (Table 1). Although there are major genes for reduced linolenate, it can be considered a quantitative trait due to the influence of environmental effects and modifying genes (Graef et al., 1988; Fehr et al., 1992). Stearate also is considered a quantitative trait and no major genes have been reported for reduction of the fatty ester.

Table 1. Soybean fatty ester alleles produced by chemical mutagenesis.

Allele	Fatty ester modification	Cultivar mutagenized	Chemical mutagen§	Line designation	Generation derived	Reference
fap1	Reduced palmitate	Century	EMS	C1726	M_2	Erickson et al., 1988
fap3	Reduced palmitate	A1937	NMU	A22	M_4	Fehr et al., 1991a
fap2	Elevated palmitate	Century	EMS	C1727	M_2	Erickson et al., 1988
fap2-b	Elevated palmitate	A1937	NMU	A21	M_4	Schnebly et al., 1994
fap4	Elevated palmitate	Elgin	EMS	A24	M_2	Fehr et al., 1991b
fap5	Elevated palmitate	Kenwood	EMS	A27	M_4	Stoltzfus et al., 2000a
fap6	Elevated palmitate	Kenwood	EMS	A25	M_4	Narvel et al., 1999
fap7	Elevated palmitate	A89-144026	NMU	A30	M_3	Stoltzfus et al., 2000b
Fas	Elevated stearate	FA9886	EMS	A9	M_2	Graef et al., 1985
fas^a	Elevated stearate	FA8077	NaN_3	A6	M_2	Graef et al., 1985
fas^b	Elevated stearate	Coles	EMS	A10	M_2	Graef et al., 1985
fan1	Reduced linolenate	Century	EMS	C1640	M_2	Wilcox and Cavins, 1987
fan1(A5)	Reduced linolenate	FA9525	EMS	A5		Hammond and Fehr, 1983
fan2	Reduced linolenate	FA47347	EMS	A23		Fehr and Hammond, 1996

§ EMS = Ethyl methanesulfonate, NMU = N-nitroso-N-methyl-urea, and NaN_3 = Sodium azide

Association of Fatty Esters with Agronomic and Seed Traits of Soybean

Wilcox et al. (1993) reported no association between seed yield and reduced linolenate due to the *fan1* allele. They indicated that the genotypic variation within the crosses would allow for selection of reduced-linolenate content and favorable agronomic traits. The association of seed yield and reduced linolenate in lines with the *fan1*(A5) *fan1*(A5) *fan2 fan2* genotype was not significant for reduced-linolenate lines in three populations evaluated by Walker et al. (1998). They did not observe significant associations of reduced linolenate with maturity, lodging, plant height, and protein content. The associations of reduced linolenate with oil and stearate content were negative and significant ($P < 0.05$) in the three populations. Differences between the means of the reduced- and normal-linolenate lines for seed weight, palmitate content and oleate content were not consistent among the three populations evaluated. They concluded that it should be possible to develop reduced-linolenate cultivars for different latitudes and production conditions.

Three studies have reported the effect of alleles for reduced-palmitate content on agronomic and seed traits of soybean. Ndzana et al. (1994) reported a significant decrease in seed yield and oil content in lines with reduced palmitate compared to lines with normal palmitate. The reduced-palmitate lines had a significantly greater protein content in two crosses and significantly lower oil content than the normal-palmitate lines in all crosses. Ndzana et al. (1994) concluded that associations of reduced palmitate with agronomic traits and seed traits could be attributable to pleiotropic effects of the *fap1* or *fap3* alleles or to possible linkages of the alleles with genes controlling other traits. In contrast, Horejsi et al. (1994) identified backcross-derived reduced-palmitate lines with seed yields comparable to the recurrent parent. Seed oil content in the reduced-palmitate lines was significantly lower than the recurrent parent. Rebetzke et al. (1998) reported that lines homozygous for the major reduced palmitate allele *fap1* had significantly lower yield than lines homozygous for the wild-type allele. The seed oil content was significantly greater among reduced-palmitate lines in one of two populations.

Hartmann et al. (1996) reported that elevated-palmitate lines had significantly later maturity, elevated plant height, and reduced lodging, seed weight, protein, oil, stearate, oleate, and linoleate

content than normal-palmitate lines. The distributions for oil content of reduced- and normal-palmitate lines were not overlapping, indicating that it may not be possible to obtain lines with elevated palmitate that have the same oil content as normal-palmitate lines.

Lundeen et al. (1987) reported no significant differences in the mean yield of high- and normal-stearate lines from crosses with A9 (*fas fas*) and A10 (fas^b fas^b). In crosses involving A6 (fas^a fas^b), the high-stearate lines had significantly lower seed yield, earlier maturity, shorter plant height, and increased lodging than normal-stearate lines.

Breeding and Testing Methods

Falconer (1960) suggested that family selection is favored when the heritability of a trait is low and the number of families is large. He discussed selection based on individual phenotypic values, the family mean, or within family selection. He stated that selection based on the mean of an individual genotype gives equal weight to selection among and within families. When selection is conducted among families, all the individuals within the selected families are kept and all the individuals in the nonselected families are discarded. For any trait, selection among and within F_2 families during subsequent inbreeding generations can be practiced by plant breeders (Fehr, 1987).

Early-generation testing (EGT) and the pedigree method (PM) are used to discard undesirable heterogeneous lines early in the breeding process, which may increase the frequency of superior lines in later generations (Fehr, 1987). One method of EGT consists of selecting individual F_2 plants with desirable characteristics from a population. The $F_{2:3}$ lines are grown as individual rows the next generation and desirable F_3 plants within the $F_{2:3}$ lines are harvested individually. The $F_{3:4}$ lines from the same F_2-derived line represent an F_2 family. The $F_{3:4}$ lines are tested and the best F_2 families are selected based on the mean performance of the $F_{3:4}$ lines of each family. The best $F_{3:4}$ lines from the best families are selected for further evaluation as pure lines. The PM involves individual plant selection in a segregating population in which the pedigree of the selected plant is maintained until homozygous lines are obtained. The method involves the selection of individual F_2 plants with desirable characteristics from a population. The $F_{2:3}$ lines are grown as individual rows the next generation and individual F_3 plants are selected from the best $F_{2:3}$ lines. The F_4 progeny from the

best F_3-derived lines are grown as an individual row. The F_4 progeny that came from the same F_3-derived line represent a family. The $F_{3:4}$ lines are tested and the best F_4 plants are selected from within the best row of the best F_3-derived family. The procedure is repeated until homozygous lines are obtained. The selected lines are evaluated in replicated tests in multiple environments.

The alternative to family selection is the evaluation of the merits of individual lines without regard to the F_2 plant from which they were derived. For the bulk method, seeds are planted each generation, plants are harvested in bulk, and a sample of seed is planted the following generation. For the single-seed-descent method, a single seed of each plant in the population is harvested and planted in bulk the following generation. Both procedures are repeated until an adequate level of homozygosity is achieved.

Several breeding methods have been compared to determine the more efficient and effective procedure. Reports regarding the effectiveness of different breeding methods have been inconsistent. The results of Raeber and Weber (1953) indicated the pedigree procedure was more effective than the bulk procedure in isolating high-yielding soybean lines. Voigt and Weber (1960) concluded that lines selected by early-generation testing were superior in yield to those selected by bulk and pedigree methods. Empig and Fehr (1971) evaluated four methods of generation advance of bulk soybean populations and found no significant differences in the mean yield of the lines from each method. Boerma and Cooper (1975), using a modified early generation testing procedure, were partially effective in identifying superior-yielding F_2-derived soybean lines, from which higher-yielding lines could be subsequently selected. Luedders et al. (1973) determined that differences in yield of lines advanced by the pedigree, bulk, and early-generation breeding methods were not significant. Ivers and Fehr (1978) reported that early-generation testing produced a greater number of superior pure lines than did pedigree selection or single-seed descent (SSD). Bravo et al. (1999) concluded that breeding methods that rely on family performance were not more efficient or effective than methods that ignore family structure for the development of cultivars with elevated palmitate.

The initial evaluation of lines from segregating soybean [*Glycine max* (L.) Merr.] populations is often limited to short-row plots grown as single replications at one environment due to limited seed

production on single plants (Boerma and Cooper, 1975; Schillinger, 1985). Plant-row-yield tests (PRYT) have been utilized in many breeding programs to eliminate inferior lines before expensive replicated trials are performed (Eberhart, 1972; Fehr, 1976). Success of the PRYT depends on the ability to minimize the risk of discarding superior genotypes and retaining inferior ones. The lines in the PRYT generally are not replicated to allow for the testing of more genotypes.

Several investigators have compared hill plots and short-row plots to replicated tests. Early generation yield-testing of single-plant progenies from segregating populations in short-row plots was found to be a useful alternative to hill plots (St. Martin et al., 1990). Pfeiffer (1987) reported that phenotypic correlation coefficients between random soybean lines in hill plots and two-row plots ranged form 0.09 to 0.43. Torrie (1962) compared elite cultivars in row plots and single-hill plots for 4 years and obtained good agreement between rows and hills for maturity, plant height, and lodging. Correlations for seed yield between rows and hills ranged from 0.26 to 0.83 among groups of lines and years of testing. Garland and Fehr (1981) suggested that randomly selected genotypes from segregating populations are the more appropriate material for experiments to determine the effectiveness of selection in short-row plots. They reported significant ($P < 0.05$) phenotypic correlation coefficients of 0.73 for seed yield between short-rows and standard plots and 0.61 between hill plots and standard plots. Heritabilities for maturity, height, and lodging were similar for hill and short-row plots. Hegstad et al. (1999) concluded that PRYT are effective for identification of elite soybean lines with high yield potential. Byrum (1999) proposed the use of molecular markers to increase the effectiveness of identifying high-yielding lines from PRYT. He concluded that the use of molecular markers alone or in combination with PRYT would be useful for selecting among lines for seed yield in a cultivar development program.

The objectives of this study were to i) compare the family and line methods of selection for reduced palmitate, palmitate + stearate (saturates), and linolenate and for seed yield of soybean, ii) determine the effectiveness and reliability of selecting high-yielding lines from unreplicated plots, and iii) determine if the *fan1*(A5) *fan1*(A5) *fan2 fan2 fap1 fap1 fap3 fap3* genotype for reduced palmitate and linolenate influences agronomic and seed traits of soybean.

MATERIALS AND METHODS

Line Development

Four populations were developed for this study. The parent lines YA7343Z006 and AX8154A370 with the *fap1 fap1 fap3 fap3* genotype for reduced palmitate content were selected for their high yield from 1993 yield tests conducted by Pioneer Hi-Bred International, Inc. The parent cultivars 9282 and 9322 with the *fan1*(A5) *fan1*(A5) *fan2 fan2* genotype for reduced linolenate also were selected for high yield from 1993 yield tests conducted by Pioneer Hi-Bred International, Inc. Each of the parents were crossed to $F_{2:3}$ lines with reduced palmitate and reduced linolenate that were selected as individual F_2 plants from segregating populations of Iowa State University that were grown at the Iowa State University–University of Puerto Rico at Isabela, Puerto Rico during January 1994. The F_2 plants were from three populations segregating for reduced palmitate and linolenate and had palmitate contents of ≤ 71 g kg^{-1} and linolenate contents of ≤ 30 g kg^{-1}.

The crosses to form the four populations were made in March 1994 in Puerto Rico. The soil type was a Coto clay (Very-fine, koalinitic, isohyperthermic, Typic Haplorthox). The crosses of $F_{2:3}$ lines with 9282 were collectively designated AX11056, with 9322 were AX11063, with YA7343Z006 were AX11080, and with AX8154A370 were AX11104. The F_1 seeds were planted in Puerto Rico in May 1994 and each F_1 plant was harvested and threshed individually. Five F_2 seeds from each F_1 plant were analyzed by gas chromatography, as described by Hammond (1991), to verify from the segregation for fatty ester content that each plant was a hybrid. Within each cross, F_2 seeds from confirmed hybrid F_1 plants were bulked.

A total of 700 F_2 seeds from each population were cut into two parts with a razor blade and the portion lacking the embryonic axis was analyzed for fatty ester content by gas chromatography during August 1994. In October 1994, 264 selected F_2 seeds for AX11056, 186 F_2 seeds for AX11063, 160 F_2 seeds for AX11080, and 97 F_2 seeds for AX11104 were planted under natural day length conditions in a 102-cm row spacing at 20 seeds m^{-1} of row. All seeds planted had <80 g kg^{-1} saturates (palmitate + stearate) and <30 g kg^{-1} linolenate. The F_2 plants were harvested individually and a bulk of five F_3 seeds from each F_2 plant was analyzed for fatty ester content. The 50 F_2 plants

with the least saturate and linolenate contents from each population were selected. The F_3 seed from the 50 F_2 plants of each population were planted in Puerto Rico in January 1995 in a 102-cm row spacing at 13 seeds m^{-1} of row and five randomly chosen individual F_3 plants from each line were harvested at random.

Testing Procedure

The five $F_{3:4}$ lines of the F_2 families of each population were grown as a separate experiment in an unreplicated PRYT at Johnston, IA during the summer of 1995. Each experiment also included 12 check lines and cultivars. The 262 entries in each experiment were subdivided into 53 blocks. The five F_3-derived lines from the same F_2 family were placed into a block, and the checks were divided at random into three blocks. Blocks and entries within blocks were randomized in each experiment. The four experiments were planted as a randomized complete-block design. The soil type was a Waukegan loam (Fine-loamy, over sandy or sandy skeletal, mixed, superactive, mesic Typic Hapludoll). A plot was a single row 108-cm long, with a 77-cm spacing between rows and a 92-cm alley between the end of plots. The seeding rate was 33 seeds m^{-1} of row. Each plot was evaluated for maturity, height, and lodging. Maturity was measured as days after 31 August when 95% of the pods within a plot had reached their mature color. Lodging was measured on a scale of 1, all plants prostrate, to 9, all plants erect. Plant height was measured at maturity in cm from the soil surface to the uppermost node on the main stem. Each plot was harvested with a self-propelled combine, the weight and moisture of the grain were measured, and the seed yield was calculated in kg ha^{-1} on a 13%-moisture basis. After harvest, the fatty ester content of each plot was determined by gas chromatography on a seven-seed bulk sample.

For the replicated tests in 1996, four random $F_{3:5}$ lines from 21 random F_2 families were used for each population. The 84 lines of each population were grown as a separate experiment. Each experiment also included 12 lines and cultivars to determine the percentage yield of the lines versus the checks and if any of the 84 $F_{3:5}$ lines had suitable agronomic performance and fatty ester composition for additional testing as potential cultivars (Table 2). The 84 experimental lines and 12

Table 2. Characterisics of check lines and cultivars for fatty ester content, genotype for major alleles contolling palmitate, and linolenate, and their maturity groups.

Cultivar or Line	Fatty ester content	Genotype	Maturity
Pioneer 9172	Normal	*Fap1 Fap3 Fan1*(A5) *Fan2*	Early Group I
Pioneer 9281	Normal	*Fap1 Fap3 Fan1*(A5) *Fan2*	Late Group II
Pioneer 9342	Normal	*Fap1 Fap3 Fan1*(A5) *Fan2*	Mid Group III
Pioneer 9381	Normal	*Fap1 Fap3 Fan1*(A5) *Fan2*	Late Group III
Pioneer 9243	Reduced palmitate	*fap1 fap3 Fan1*(A5) *Fan2*	Mid Group II
YB27G	Reduced palmitate	*fap1 fap3 Fan1*(A5) *Fan2*	Late Group II
YA7343Z006	Reduced palmitate	*fap1 fap3 Fan1*(A5) *Fan2*	Mid Group II
AX8154A370	Reduced palmitate	*fap1 fap3 Fan1*(A5) *Fan2*	Late Group II
XB26C	Reduced palmitate	*fap1 fap3 Fan1*(A5) *Fan2*	Mid Group II
XB36I	Reduced linolenate	*Fap1 Fap3 fan1*(A5) *fan2*	Mid Group III
Pioneer 9253	Reduced linolenate	*Fap1 Fap3 fan1*(A5) *fan2*	Mid Group II
Pioneer 9282	Reduced linolenate	*Fap1 Fap3 fan1*(A5) *fan2*	Late Group II
Pioneer 9322	Reduced linolenate	*Fap1 Fap3 fan1*(A5) *fan2*	Early Group III

checks of each experiment were subdivided into 24 blocks. A block consisted of the four F_3-derived lines from the same F_2 family or four of the check lines and cultivars. Blocks and entries within blocks were randomized in each replication. The four experiments were planted as a randomized complete-block design with two replications at Ames, Atlantic, and Washington, IA and Bethany, MO in 1996. Soil types at the locations were a Nicollet loam (Fine-loamy, mixed, mesic Aquic Hapludoll) at Ames, a Marshall silt loam (Fine-silty, mixed, superactive, mesic Typic Hapludoll) at Atlantic, a Mahaska silty clay loam (Fine, smetitic, mesic Aquertic Argiudoll) at Washington, and a Haig silt loam (Fine, smetitic, mesic Vertic Argiaquoll) at Bethany. A plot consisted of paired rows 3.7 m long, with a 77-cm row spacing and a 92-cm alley between the end of plots. The seeding rate was 31 seeds per m^{-1} of row. Each plot was evaluated for maturity, height, lodging, seed yield, and protein, oil, and fatty ester content. Maturity was measured at Ames, Altantic, and Washington as days after 31 August when 95% of the pods within a plot had reached their mature color. Lodging was measured at Ames,

Atlantic, and Washington on a scale of 1, all plants prostrate, to 9, all plants erect. Plant height was measured at maturity at Ames, Atlantic, and Washington in cm from the soil surface to the uppermost node on the main stem. Each plot was harvested with a self-propelled combine, the weight and moisture of the grain were measured, and the seed yield was calculated in kg ha^{-1} on a 13%-moisture basis. After harvest, the fatty ester content of each plot was determined by gas chromatography on a seven-seed bulk sample. A bulk sample of ≈ 600 seeds from plots from Ames and Washington were evaluated with a Tacator A/B (Hooganas, Sweden) Infretech 1221 whole grain near-infrared reflectance analyzer for moisture, protein and oil content. Seed yield, protein and oil content were adjusted to 13% moisture.

Data Analysis

For comparison of the family and line methods, selection was practiced independently for ≤ 38 g kg^{-1} palmitate, ≤ 70 g kg^{-1} palmitate + stearate (saturates), ≤ 35 g kg^{-1} linolenate, the combination of ≤ 70 g kg^{-1} saturates and ≤ 35 g kg^{-1} linolenate, and ≥ 87% seed yield of check lines and cultivars. The criteria for palmitate, linolenate, and seed yield were chosen so that ≈ 50% of the lines would be selected when averaged across populations and selection environments. The use of ≤ 70 g kg^{-1} saturates was based on the approximate content of palmitate and stearate that could be in an oil that would meet the standard established by the Food and Drug Administration for an oil that could be labeled as low in saturated fat (U.S. FDA, 1994).

For the family method, the mean content of the four F_3-derived lines within a F_2 family was determined. Within families that had a palmitate content of ≤ 38 g kg^{-1}, lines with ≤ 38 g kg^{-1} palmitate were selected. For the line method, individual lines with ≤ 38 g kg^{-1} palmitate were selected without regard to the family performance. For saturates, families that had saturates of ≤ 70 g kg^{-1}, lines with ≤ 70 g kg^{-1} saturate were selected. For the line method, individual lines with ≤ 70 g kg^{-1} saturate were selected without regard to the family performance. For linolenate, families that had a linolenate content of ≤ 35 g kg^{-1}, lines with ≤ 35 g kg^{-1} linolenate were selected. For the line method, individual lines with ≤ 35 g kg^{-1} linolenate were selected without regard to the family performance. For the combination of saturates and linolenate, families that had saturates of ≤ 70 g kg^{-1} and linolenate of ≤

35 g kg^{-1}, lines with ≤ 70 g kg^{-1} saturates and ≤ 35 g kg^{-1} linolenate were selected. For the line method, individual lines with ≤ 70 g kg^{-1} saturates and ≤ 35 g kg^{-1} linolenate were selected without regard to the family performance. For seed yield, families that had a seed yield of ≥ 87% of the checks, lines with ≥ 87% seed yield were selected. For the line method, individual lines with ≥ 87% seed yield were selected without regard to the family performance.

Selection for each of the five traits by the family and line methods was conducted independently in each of the five environments based on the PRYT in 1995 and on individual replications at the four locations in 1996. To compare the usefulness of one or two replications at a single location, selection by the family and line methods also was based on the mean of the two replications at the 1996 locations. The PRYT performance was compared with the mean performance of the lines at the four locations in 1996. The selection practiced at one location in 1996 was compared with the mean performance of the lines at the other three locations in 1996. Acceptance and rejection errors were calculated for both methods of selection. Acceptance error occurred when lines were chosen based on the PRYT or one or two replications of testing in one selection environment, but the lines did not meet the selection criterion based on their mean in the other environments. Rejection error occurred when lines were not chosen because they did not meet the selection criterion in the selection environment, but the lines met the criterion based on their mean in the other environments.

Lines from the PRYT and in each of the four replicated environments based on the two individual replications and the mean of the two replications were ranked for seed yield. The ranking of lines in one replication and the mean of two replications at one environment were compared with their ranking for seed yield in the test environments. Selection intensities required to retain the highest yielding line or one or more of the 10 highest yielding lines from replicated tests was determined.

The data from each experiment were analyzed as a randomized complete-block design for individual environments and across environments (Tables 3 and 4). All variables in the analysis of variance were considered random effects. The analyses of variance were performed using the general linear models procedure (GLM) of the SAS software package (release 6.12) (SAS Institute, 1992). The following model was used for the analyses of individual environments:

$$Y_{ijk} = \mu + R_i + F_j + S_{k/j} + e_{ijk}$$

where,

Y_{ijk} = observed value of the k^{th} line in the j^{th} family in the i^{th} replication,

μ = the overall mean,

R_i = the effect of the i^{th} replication,

F_j = the effect of the j^{th} family,

$S_{k/j}$ = the effect of the k^{th} line within the j^{th} family, and

e_{ijk} = the error of the ijk^{th} observation.

Table 3. Analysis of variance for individual environments.

Sources of Variation	df	Mean Squares	Expected Mean Squares
Replications (R)	(r-1)	M_4	$\sigma^2_e + fl\sigma^2_R$
F_2 Families (F)	(f-1)	M_3	$\sigma^2_e + r\sigma^2_{L/F} + rl\sigma^2_F$
Lines within F(L/F)	f(l-1)	M_2	$\sigma^2_e + r\sigma^2_{L/F}$
Error	(fl-1)	M_1	σ^2_e
Total	(rfl-1)		

Table 4. Analysis of variance for combined environments.

Sources of Variation	df	Mean Squares	Expected Mean Squares
Environments (E)	(e-1)	N_7	$\sigma^2_e + r\sigma^2_{E(L/F)} + rl\sigma^2_{EF} + fl\sigma^2_{R/E} + rfl\sigma^2_E$
Replications in E(R/E)	E(r-1)	N_6	$\sigma^2_e + fl\sigma^2_{R/E}$
F_2 Families (F)	(f-1)	N_5	$\sigma^2_e + r\sigma^2_{E(L/F)} + rl\sigma^2_{EF} + er\sigma^2_{L/F} + erl\sigma^2_F$
Lines in F(L/F)	f(l-1)	N_4	$\sigma^2_e + r\sigma^2_{E(L/F)} + er\sigma^2_{L/F}$
E x F	(e-1)(f-1)	N_3	$\sigma^2_e + r\sigma^2_{E(L/F)} + rl\sigma^2_{EF}$
E x (L/F)	(e-1)f(l-1)	N_2	$\sigma^2_e + r\sigma^2_{E(L/F)}$
Error	(r-1)e(fl-1)	N_1	σ^2_e
Total	(erfl-1)		

For the combined analysis across environments, the following model was used:

$$Y_{ijkl} = \mu + E_i + D_{j/i} + F_k + B_{l/k} + C_{ik} + M_{il/k} + e_{ijkl}$$

where,

Y_{ijkl} = observed value of the l^{th} line within the k^{th} family in the j^{th} replication of the i^{th} environment,

μ = the overall mean,

E_i = the effect of the i^{th} environment,

$D_{j/i}$ = the effect of the j^{th} replication within the i^{th} environment,

F_k = the effect of the k^{th} family,

$B_{l/k}$ = the effect of the l^{th} line within the k^{th} family,

C_{ik} = the effect of the interaction between the i^{th} environment and the k^{th} family,

$M_{il/k}$ = the effect of the interaction between the i^{th} environment and the l^{th} line within the k^{th} family, and

e_{ijkl} = the error of the $ijkl^{th}$ observation.

The variation among families and lines within the families were evaluated using F-tests (Steel and Torrie, 1980). The F-tests in the individual environments were calculated as follows:

F-test for replication = M_4 / M_1

F-test for F_2 families = M_3 / M_2

F-test for lines in families = M_2 / M_1

The F-tests conducted for combined environments were calculated as follows:

F-test for environments = $N_7 / (N_6 + N_3 - N_1)$

F-test for replications within environments = N_6 / N_1

F-test for F2 families = $N_5 / (N_3 + N_4 - N_2)$

F-test for lines in families = N_4 / N_2

F-test for environments x families = N_3 / N_2

F-test for environments x lines within families = N_2 / N_1

Phenotypic correlation coefficients were calculated between agronomic and seed traits based on the mean performance of lines across environments. The phenotypic correlation coefficients were calculated on the data using CORR of the SAS software package (SAS Institute, 1992). Chi-square analysis was made to determine if selection from the PRYT and in one or two replications at one location was better than random selection of lines.

Heritability estimates were calculated on a plot and entry-mean basis (Fehr, 1987). The heritabilities were calculated as follows:

$$\text{Plot basis } h^2 = \frac{\sigma^2_G}{\sigma^2_e + \sigma^2_{GE} + \sigma^2_G} \qquad \text{Entry-mean basis } h^2 = \frac{\sigma^2_G}{\sigma^2_e/re + \sigma^2_{GE}/e + \sigma^2_G}$$

The standard error for the heritability estimates were calculated (Hallauer and Miranda, 1981).

$$\text{SE for plot basis } h^2 = \frac{\text{SE } \sigma^2_G}{\sigma^2_e + \sigma^2_{GE} + \sigma^2_G}$$

$$\text{SE for entry-mean basis } h^2 = \frac{\text{SE } \sigma^2_G}{(\sigma^2_e)/re + (\sigma^2_{GE})/e + \sigma^2_G}$$

The variance components and their standard errors for each cross were calculated from the combined analyses of variance across environments (Hallauer and Miranda, 1981).

Genetic variance component:

$$\sigma^2_G = \frac{[\{(N_5 \times df_F) + (N_4 \times df_{L/F})\}/(df_F + df_{L/F})] - [\{(N_2 \times df_{E(L/F)}) + (N_3 \times df_{EF})\}/(df_{E(L/F)} + df_{EF})]}{re}$$

SE for the genetic variance component:

$$SE(\sigma^2_G) = \left(\frac{\{2/(re)^2\}[\{(N_5 \times df_F) + (N_4 \times df_{L/F})\}/(df_F + df_{L/F})]^2}{(df_F + df_{L/F} + 2)} - \frac{[\{(N_2 \times df_{E(L/F)}) + (N_3 \times df_{EF})\}/(df_{E(L/F)} + df_{EF})]^2}{(df_{EF} + df_{E(L/F)} + 2)} \right)^{1/2}$$

Genotype x environment variance component:

$$\sigma^2_{GE} = \frac{[\{(N_2 \times df_{E(L/F)}) + (N_3 \times df_{EF})\}/(df_{E(L/F)} + df_{EF})] - N_1}{r}$$

SE for the genotype x environment variance component:

$$SE(\sigma^2_{GE}) = \left[\frac{\{2/(r)^2\}\,[\{(N_2 \times df_{E(L/F)}) + (N_3 \times df_{EF})\}/(df_{E(L/F)} + df_{EF})]^2}{(df_{EF} + df_{E(L/F)} + 2)} + \frac{(N_1)^2}{(df_e + 2)} \right]^{1/2}$$

Error variance component: $\sigma^2_e = N_1$

$$\text{SE of the error variance component} = \left[\frac{2(N_1)^2}{(df_e - 2)} \right]^{1/2}$$

Least significant differences (LSD) at the 0.05 and 0.01 probability levels, standard errors of the mean (SE) and coefficients of variation (CV) were calculated (Steel and Torrie, 1980).

$LSD = t\alpha\,[2 \times MSE/n]^{1/2}$ $SE = (MSE/n)^{1/2}$ $CV = (\sigma^2_e)^{1/2} / \overline{X}$.

The LSD for families and lines for the combined environments was calculated as:

$$\text{Families LSD} = t\alpha\,\{[2 \times (N_4 + N_3 - N_2)] \div elr\}^{1/2}$$

$$\text{Lines LSD} = t\alpha\,\{[2 \times [N_3/df_{EF}) + (N_2/df_{E(L/F)})] \div er\}^{1/2}$$

The LSD for families and lines at individual environments were calculated as:

$$\text{Families LSD} = t\alpha\,[(2 \times M_2) \div rl\}^{1/2}$$

$$\text{Lines LSD} = t\alpha\,\{[2 \times (M_1)] \div r\}^{1/2}$$

The SE for families and lines across environments was calculated as:

$$\text{Family SE} = [(N_4 + N_3 - N_2) \div erl\}^{1/2}$$

$$\text{Lines SE} = \{[(N_3/df_{EF}) + (N_2/df_{E(L/F)})] \div er\}^{1/2}$$

The SE for family and lines at individual environments were calculated as:

$$\text{Family SE} = [(M_2) \div rl]^{1/2}$$

$$\text{Lines SE} = [(M_1) \div r]^{1/2}$$

The Satterthwaite equation was used to obtain the effective degrees of freedom for families across environments (Steel and Torrie, 1980, pp. 357). The equation for each cross was calculated as:

$$p = \frac{(N_4 + N_3 - N_2)^2}{(N_4^2/df_{L/F}) + N_3^2/df_{EF}) - N_2^2/df_{E(L/F)}}$$

The symbols used in the above equations were as follows:

SE = standard error of the mean.

M_1 = error mean square.

M_2 = lines in families mean square.

M_3 = families mean square.

M_4 = replication mean square.

N_1 = error mean square .

N_2 = environments x lines within families mean square.

N_3 = environments x families mean square.

N_4 = lines within families mean square.

N_5 = families mean square.

σ^2_G = genetic variance component.

σ^2_{GE} = genotype x environment variance component.

σ^2_e = error variance component.

$df_{E(L/F)}$ = degrees of freedom associated with N2.

df_{EF} = degrees of freedom associated with N3.

$df_{L/F}$ = degrees of freedom associated with N4.

df_F = degrees of freedom associated with N5.

e = number of environments.

l = number of lines in a family.

r = number of replications per environment.

$t\alpha$ = t value at the 0.05 and 0.01 probability levels.

n = number of plots used to calculate the mean.

σ^2_e = experimental error.

$\bar{x}$ = mean.

p = effective degrees of freedom.

RESULTS

There were significant ($P < 0.01$) differences among the four environments in 1996 for mean seed yield and linolenate in the four populations (Tables 5 to 8). There were no significant differences among environments for palmitate. There were significant ($P < 0.05$) differences in saturates among environments for AX11056 and AX11104, but the differences were not significant for AX11063 and AX11080.

There were significant ($P > 0.01$) differences among families and among lines for seed yield and linolenate in the four populations, indicating that selection among families and among lines within families should be effective (Tables 5 to 8). There were significant ($P < 0.05$) differences among families for palmitate and saturates for AX11056, AX11063, and AX11080, but not for AX11104. The differences among lines within families for palmitate and saturates were significant ($P < 0.01$) in the four populations.

The environments x families interaction was significant for seed yield and linolenate in all populations due to the change in rank of families among environments (Tables 5 to 8). The interaction was significant for palmitate and saturates for AX11063 and AX11104, but not significant for AX11056 and AX11080. The environments x lines within families interaction for seed yield was not significant in any of the populations, indicating that selection among lines within families could be based on the evaluation in one environment (Tables 5 to 8). The environment x lines within families interactions for palmitate, saturates and linolenate were significant in some of the four populations.

The number of lines selected for palmitate, saturates, linolenate, the combination of saturates and linolenate, and for seed yield by the family method was less than for the line method in all populations (Tables 9 to 14). This occurred because a line could not be chosen if it was in a family that did not meet the selection criterion. The lower percentage of lines selected for the combination of saturates and linolenate compared with single trait selection indicated that combining the two traits would reduce the frequency of acceptable lines in a segregating population.

Even though fewer lines were chosen by the family method, the acceptance error was similar for the two selection methods (Tables 9 to 14). The lower acceptance error associated with selection for

the combination of saturates and linolenate indicated that selection for the two traits would be less reliable than selection for the individual traits.

The frequency of rejection error was higher for the family than for the line method in all populations and for all traits. The greater rejection error for the family method reflected the limitation that a line could not be selected if its family exceeded the selection criterion. The greater rejection error for the combination of saturates and linolenate reflected the lower reliability of selection than for the individual traits.

The reliability of selection based on one replication was similar to that of selection based on the mean of two replications (Tables 9 to 13). Use of a single replication at a location should suffice for the evaluation of palmitate, saturates, linolenate, and seed yield. On average, similar selection intensities were obtained for PRYT and for one or two replications at a location in 1996 to retain the highest yielding line or to retain one or more of the ten highest yielding lines from replicated tests in 1996 (Tables 15 and 16). The data indicated that one replication of PRYT was as effective at identifying high-yielding lines from segregating population as replicated tests. The use of replication at a location would allow the investigator to obtain an estimate of experimental error; however, replication would reduce the number of genotypes that could be tested each year given fixed resources.

The percentage of lines that had to be selected in the PRYT to retain the highest yielding lines in the replicated tests ranged from 2 to 35% for the four populations (Table 15). An average selection intensity of 3% in PRYT was required to retain one of the 10 highest yielding lines from replicated tests, but an average selection intensity of 61% was required to retain all the top 10 lines. Selection intensities required to retain the highest yielding lines in the PRYT were similar to those for the use of one or two replications at individual locations in 1996 (Table 16).

A Chi-square test was used to determine if selection based on the PRYT was superior to random selection of lines for advanced testing. Selection in the PRYT was not significantly different from random selection, ($\chi^2 = 5.39$, $P < 0.15$) (Table 17). Selection from individual replications at a location

in 1996 was significantly ($P < 0.01$) different from random selection ($\chi^2 = 11.03$, $P < 0.01$) as was selection based on the mean of the two replications at a location in 1996 ($\chi^2 = 12.63$, $P < 0.01$).

Phenotypic correlation coefficients between the PRYT and the mean of the replicated tests averaged across environments were significant and positive for all traits and populations, except saturates, for which the correlations were inconsistent among populations (Table 18). Phenotypic correlation coefficients between PRYT and the mean of individual locations were positive and significant ($P > 0.05$) for all comparisons and populations, except Bethany vs. PRYT (Table 19). The correlation coefficients between Bethany and the PRYT were inconsistent among populations. Phenotypic correlation coefficients between the PRYT and the overall mean of the replicated tests were positive and significant for all populations. Phenotypic correlation coefficients between the mean of individual locations were significant and positive for all comparisons. Phenotypic correlation coefficients between individual replications and the mean of the other environments were positive and significant for all comparisons. The correlation coefficients between the mean of the two replications and the mean of the other environments were also positive and significant for all environments. The phenotypic correlation coefficients indicated that the PRYT would be an effective testing strategy to identify high-yielding experimental lines. Additionally, the difference between correlations for single replications and two replications indicated that the use of replication at testing environments may not be necessary for identifying high-yielding experimental lines.

Phenotypic correlation coefficients between seed yield and palmitate and saturates were not significant in the four populations (Tables 20 to 23). Selection of high-yielding lines with reduced saturate content should be possible. The correlation coefficients between seed yield and lodging, linolenate, protein content, and oil content were not consistent among the populations. For the development of cultivars with reduced linolenate, multiple parents should be utilized for developing populations.

Phenotypic correlation coefficients between palmitate and maturity, lodging, and oil content were not significant in the four populations (Tables 20 to 23). The correlation coefficients between palmitate and height and protein content were not consistent among the populations. For the

development of cultivars with reduced palmitate, multiple parents should be utilized for population development. Phenotypic correlation coefficients between saturates and height and protein content were not significant in the four populations. The correlation coefficients between saturates and maturity, height, and oil content were not consistent among the populations. For the development of cultivars with reduced saturates, multiple parents should be utilized. Phenotypic correlation coefficients between linolenate and maturity, height, lodging, oil content, and protein content were not consistent among the four populations.

Phenotypic correlation coefficients among the fatty esters were inconsistent among the four populations (Tables 20 to 23). Selection of reduced palmitate and linolenate lines with desirable agronomic and seed traits should be possible.

Table 5. Analysis of variance for population AX11056 combined across four environments in 1996.

Sources of variation	df	Mean squares Seed yield	df	Mean squares Maturity	Height	Lodging	df	Mean squares Protein	Oil
Environments (E)	3	72799050**	2	6286**	10327**	29**	1	28844**	11523*
Replications within E (R/E)	4	2043255**	3	50**	382**	0.6	2	51	119*
F2 Families (F)	20	1861907**	20	340**	711**	16**	20	1091**	511**
Lines within Families (L/F)	63	182012**	63	17**	61**	1.4**	63	117**	143**
E * F	60	294295**	40	9.0**	44**	1.5**	20	87**	51*
E * (L/F)	189	87729	126	1.3	18	0.4	63	22	26
Error	332	74564	249	2.0	19	0.4	166	31	29
CV (%)		9.2		4.4	5.2	9.7		1.6	3.4
No. of environments		4		3	3	3		2	2

*, ** Significant at the 0.05 and 0.01 probability level, respectively.

Table 5. (Cont.)

		Mean squares					
Sources of variation	df	Palmitate	Stearate	Oleate	Linoleate	Linolenate	Saturates
Environments (E)	3	52	420**	67732**	49735**	2450**	755*
Replications within E (R/E)	4	51**	7.9	854*	794*	189**	59*
F2 Families (F)	20	110**	185**	26804**	27997**	109*	202*
Lines within Families (L/F)	63	50**	15**	2601**	2480**	44**	93**
E * F	60	11	9.7**	832**	759**	21**	29
E * (L/F)	189	14*	6.1	260	268	12	28
Error	332	11	6.0	268	260	15	23
CV (%)		8.8	8.0	6.9	2.4	11	7.1
No. of environments		4	4	4	4	4	4

Table 6. Analysis of variance for population AX11063 combined across four environments in 1996.

		Mean squares		Mean squares				Mean squares	
Sources of variation	df	Seed yield	df	Maturity	Height	Lodging	df	Protein	Oil
Environments (E)	3	72655868**	2	6169**	13529*	90*	1	26129	37212
Replications within E (R/E)	4	1792438**	3	84**	987**	16**	2	1393**	333**
F2 Families (F)	20	5067011**	20	406**	1816**	13**	20	1970**	570**
Lines within Families (L/F)	63	405582**	63	40**	118**	1.7**	63	108**	76**
E * F	60	370234**	40	14**	68**	2.2**	20	238**	50**
E * (L/F)	189	69605	126	1.1	22	0.4	63	35*	9.0
Error	332	79362	249	2.0	23	0.5	166	24	10
CV (%)		9.0		4.4	5.6	9.9		1.5	1.8
No. of environments		4		3	3	3		2	2

*, ** Significant at the 0.05 and 0.01 probability level, respectively.

Table 6. (Cont.)

		Mean squares					
Sources of variation	df	Palmitate	Stearate	Oleate	Linoleate	Linolenate	Saturates
Environments (E)	3	120	370	50500**	31166**	1944**	904
Replications within E (R/E)	4	55**	213**	816**	2594**	11	476**
F2 Families (F)	20	400**	104**	16909**	19922**	208**	652**
Lines within Families (L/F)	63	61**	11**	1314**	1223**	54**	83**
E * F	60	20**	13**	634**	593**	22**	43**
E * (L/F)	189	12*	4.8	203*	213	12*	23**
Error	332	9.3	4.8	164	183	9.4	17
CV (%)		7.7	6.5	5.3	2.1	9.2	5.6
No. of environments		4	4	4	4	4	4

Table 7. Analysis of variance for population AX11080 combined across four environments in 1996.

		Mean squares		Mean squares				Mean squares	
Sources of variation	df	Seed yield	df	Maturity	Height	Lodging	df	Protein	Oil
Environments (E)	3	65085562**	2	7204**	16448**	71**	1	31489*	1734
Replications within E (R/E)	4	786924**	3	5.5**	101**	2.8**	2	715**	89*
F2 Families (F)	20	3574468**	20	714**	2134**	9.5**	20	1378**	1081**
Lines within Families (L/F)	63	759734**	63	54**	225**	1.4**	63	147**	87**
E * F	60	285334**	40	7.3**	50**	1.6**	20	105**	112**
E * (L/F)	189	67432	126	2.5*	24	0.3**	63	38*	26
Error	332	76607	249	1.8	24	0.2	166	25	25
CV (%)		9.3		4.3	6.4	6.4		1.5	3.1
No. of environments		4		3	3	3		2	2

*, ** Significant at the 0.05 and 0.01 probability level, respectively.

Table 7. (Cont.)

		Mean squares					
Sources of variation	df	Palmitate	Stearate	Oleate	Linoleate	Linolenate	Saturates
Environments (E)	3	50	264	82663**	67351**	2075**	478
Replications within E (R/E)	4	44**	134**	468	1666**	58**	322**
F2 Families (F)	20	74**	407**	17836**	18914**	270**	649**
Lines within Families (L/F)	63	18**	22**	1775**	1735**	42**	46**
E * F	60	9.7	15**	797**	814**	22*	35
E * (L/F)	189	11	8.5	281	306	14	29
Error	332	9.8	7.6	254	275	15	27
CV (%)		8.5	8.7	6.8	2.5	11	7.6
No. of environments		4	4	4	4	4	4

Table 8. Analysis of variance for population AX11104 combined across four environments in 1996.

Sources of variation	df	Mean squares Seed yield	df	Mean squares Maturity	Height	Lodging	df	Mean squares Protein	Oil
Environments (E)	3	95088965**	2	7418**	12558**	28**	1	4037	19160
Replications within E (R/E)	4	294228**	3	14**	13	0.4	2	281**	366**
F2 Families (F)	20	1346015**	20	637**	1250**	12**	20	887**	590**
Lines within Families (L/F)	63	721609**	63	75**	189**	1.9**	63	96**	103**
E * F	60	262063**	40	11**	63**	2.1**	20	44*	54**
E * (L/F)	189	72366	126	2.9	21	0.6**	63	21	11
Error	332	67781	249	2.4	18	0.2	166	16	9.0
CV (%)		9.0		5.2	5.1	6.7		1.1	1.7
No. of environments		4		3	3	3		2	2

*, ** Significant at the 0.05 and 0.01 probability level, respectively.

Table 8. (Cont.)

		Mean squares					
Sources of variation	df	Palmitate	Stearate	Oleate	Linoleate	Linolenate	Saturates
Environments (E)	3	29	188**	32661**	24547**	1428**	256*
Replications within E (R/E)	4	7.9	2.1	321	266	9.0	4.0
F2 Families (F)	20	146	39**	11780**	15976**	1283**	163
Lines within Families (L/F)	63	174**	8.1**	1113**	795**	151**	194**
E * F	60	17*	10**	614**	619**	19*	36*
E * (L/F)	189	11	5.1	226**	261**	12	24*
Error	332	9.5	5.0	143	168	12	19
CV (%)		8.0	6.8	5.3	1.9	9.5	6.1
No. of environments		4	4	4	4	4	4

Table 9. Errors associated with selection by the family and line methods for ≤ 38 g kg^{-1} palmitate content among four F_3-derived lines from each of 21 families for each of four populations averaged across four selection environments in 1996.

Population and basis	Family method							Line method						
	Lines selected	Error						Lines selected	Error					
		None		Acceptance		Rejection			None		Acceptance		Rejection	
	no.	no.	%†	no.	%‡	no.	%§	no.	no.	%†	no.	%‡	no.	%§
AX11056														
Individual rep	61	56	92	5	8	16	23	68	61	89	7	11	11	15
Rep mean	65	59	91	6	9	13	18	68	60	90	7	10	12	16
AX11063														
Individual rep	36	23	63	13	37	21	48	47	28	60	19	40	15	35
Rep mean	35	21	59	14	41	23	53	44	26	59	18	41	18	40
AX11080														
Individual rep	61	53	87	8	13	16	23	66	57	86	9	14	12	18
Rep mean	62	54	87	8	13	15	22	65	57	87	9	13	12	18
AX11104														
Individual rep	47	37	79	10	21	24	39	60	47	78	13	22	14	23
Rep mean	47	38	81	9	19	23	38	56	45	80	11	20	16	26

† None % = (no. of lines selected without error ÷ no. of lines selected) x 100.
‡ Acceptance % = (no. of lines incorrectly accepted ÷ no. of lines selected) x 100.
§ Rejection % = [no. of lines incorrectly rejected ÷ (no. of lines selected without error + no. of lines incorrectly rejected)] x 100.

Table 10. Errors associated with selection by the family and line methods for ≤ 70 g kg^{-1} saturate content among four F_3-derived lines from each of 21 families for each of four populations averaged across four selection environments in 1996.

Population and basis	Family method							Line method						
	Lines selected	Error						Lines selected	Error					
		None		Acceptance		Rejection			None		Acceptance		Rejection	
	no.	no.	%†	no.	%‡	no.	%§	no.	no.	%†	no.	%‡	no.	%§
AX11056														
Individual rep	56	45	80	11	20	21	32	62	49	79	13	21	17	26
Rep mean	58	46	79	13	21	20	30	62	50	80	13	20	16	24
AX11063														
Individual rep	23	11	47	13	53	14	55	33	14	42	19	58	11	43
Rep mean	22	10	46	12	54	15	59	30	13	42	18	58	12	49
AX11080														
Individual rep	43	36	84	7	16	17	32	52	40	77	12	23	13	25
Rep mean	46	39	83	8	17	15	28	52	41	78	11	22	13	23
AX11104														
Individual rep	30	16	55	13	45	23	59	44	24	55	20	45	15	38
Rep mean	26	14	54	12	46	26	65	39	21	53	19	47	19	48

† None % = (no. of lines selected without error ÷ no. of lines selected) x 100.
‡ Acceptance % = (no. of lines incorrectly accepted ÷ no. of lines selected) x 100.
§ Rejection % = [no. of lines incorrectly rejected ÷ (no. of lines selected without error + no. of lines incorrectly rejected)] x 100.

Table 11. Errors associated with selection by the family and line methods for ≤ 35 g kg^{-1} linolenate content among four F_3-derived lines from each of 21 families for each of four populations averaged across four selection environments in 1996.

Population and basis	Family method							Line method						
	Lines selected	Error						Lines selected	Error					
		None		Acceptance		Rejection			None		Acceptance		Rejection	
	no.	no.	%†	no.	%‡	no.	%§	no.	no.	%†	no.	%‡	no.	%§
AX11056														
Individual rep	38	18	48	20	52	26	59	48	24	51	24	49	20	45
Rep mean	38	18	47	20	53	27	60	45	23	51	22	49	21	48
AX11063														
Individual rep	56	50	91	5	9	23	31	63	57	91	6	9	16	22
Rep mean	57	51	89	6	11	22	30	61	55	92	6	10	17	24
AX11080														
Individual rep	43	31	70	13	30	22	41	52	36	70	16	30	16	31
Rep mean	44	31	71	13	29	22	41	49	35	71	14	29	18	34
AX11104														
Individual rep	35	26	75	9	25	20	43	44	33	75	11	25	13	28
Rep mean	36	27	75	9	25	19	41	42	32	76	10	24	14	30

† None % = (no. of lines selected without error ÷ no. of lines selected) x 100.
‡ Acceptance % = (no. of lines incorrectly accepted ÷ no. of lines selected) x 100.
§ Rejection % = [no. of lines incorrectly rejected ÷ (no. of lines selected without error + no. of lines incorrectly rejected)] x 100.

Table 12. Errors associated with selection by the family and line methods for ≤ 70 g kg^{-1} saturate content and ≤ 35 g kg^{-1} linolenate content among four F_3-derived lines from each of 21 families for each of four populations averaged across four selection environments in 1996.

Population and basis	Family method							Line method						
	Lines selected	Error						Lines selected	Error					
		None		Acceptance		Rejection			None		Acceptance		Rejection	
	no.	no.	%†	no.	%‡	no.	%§	no.	no.	%†	no.	%‡	no.	%§
AX11056														
Individual rep	22	9	41	13	59	23	72	32	13	41	19	59	19	59
Rep mean	22	9	41	13	59	25	73	30	13	43	17	57	20	61
AX11063														
Individual rep	17	5	30	12	70	16	76	24	8	33	17	67	14	63
Rep mean	17	5	30	12	70	16	76	23	6	27	16	73	15	71
AX11080														
Individual rep	20	11	57	9	43	18	62	30	15	49	15	51	15	50
Rep mean	22	13	57	10	43	10	44	28	15	52	14	48	8	36
AX11104														
Individual rep	10	4	40	6	60	17	80	21	9	42	12	56	11	56
Rep mean	10	5	50	5	50	16	76	17	7	41	10	57	14	66

† None % = (no. of lines selected without error ÷ no. of lines selected) x 100.
‡ Acceptance % = (no. of lines incorrectly accepted ÷ no. of lines selected) x 100.
§ Rejection % = [no. of lines incorrectly rejected ÷ (no. of lines selected without error + no. of lines incorrectly rejected)] x 100.

Table 13. Errors associated with selection by the family and line methods for ≥ 87% of the seed yield of check genotypes among four F_3-derived lines from each of 21 families for each of four populations averaged across four selection environments in 1996.

Population and basis	Family method							Line method						
	Lines selected	Error						Lines selected	Error					
		None		Acceptance		Rejection			None		Acceptance		Rejection	
	no.	no.	%†	no.	%‡	no.	%§	no.	no.	%†	no.	%‡	no.	%§
AX11056														
Individual rep	46	37	80	9	20	21	36	51	40	78	11	22	17	30
Rep mean	50	41	82	9	18	17	29	55	44	80	11	20	14	24.
AX11063														
Individual rep	60	55	92	5	8	15	22	64	59	92	5	8	12	16
Rep mean	63	59	94	4	6	11	16	65	61	94	4	6	9	13
AX11080														
Individual rep	30	24	82	5	18	21	47	41	33	80	8	20	13	28
Rep mean	32	27	85	5	15	19	41	41	33	80	8	20	13	28
AX11104														
Individual rep	28	20	71	8	29	20	50	40	28	71	12	29	11	28
Rep mean	26	19	73	7	27	21	52	39	29	75	10	25	11	27

† None % = (no. of lines selected without error + no. of lines selected) x 100.
‡ Acceptance % = (no. of lines incorrectly accepted + no. of lines selected) x 100.
§ Rejection % = [no. of lines incorrectly rejected + (no. of lines selected without error + no. of lines incorrectly rejected)] x 100.

Table 14. Errors associated with selection by the family and line methods for ≤ 38 g kg^{-1} palmitate content, ≤ 35 g kg^{-1} content, < 70 g kg^{-1} saturate content, ≥ 87% seed yield of check genotypes and the combination ≤ 70 g kg^{-1} saturate content and ≤ 35 g kg^{-1} linolenate content among four F_3-derived lines from each of 21 families in four populations from plant-row-yield tests in 1995.

Trait and population	Family method							Line method						
	Lines selected	Error						Lines selected	Error					
		None		Acceptance		Rejection			None		Acceptance		Rejection	
	no.	no.	%†	no.	%‡	no.	%§	no.	no.	%†	no.	%‡	no.	%§
Palmitate														
AX11056	61	59	97	2	3	16	21	66	64	97	2	3	11	15
AX11063	71	45	63	26	37	3	6	74	47	64	27	36	1	2
AX11080	55	49	89	6	11	23	32	64	57	89	7	11	15	21
AX11104	58	46	79	12	21	14	23	68	53	78	15	22	7	12
Saturates														
AX11056	64	51	80	13	20	16	24	68	55	81	13	19	12	18
AX11063	13	7	54	6	46	19	73	28	14	50	14	50	12	46
AX11080	37	24	65	13	35	31	56	47	33	70	14	30	22	40
AX11104	51	24	47	27	53	17	41	64	33	52	31	48	8	20
Linolenate														
AX11056	83	44	53	39	47	0	0	83	44	53	39	47	0	0
AX11063	84	75	89	9	11	0	0	84	75	89	9	11	0	0
AX11080	82	50	61	32	39	0	0	82	50	61	32	39	0	0
AX11104	64	42	66	22	34	1	2	69	43	62	26	38	0	0

† None % = (no. of lines selected without error ÷ no. of lines selected) x 100.
‡ Acceptance % = (no. of lines incorrectly accepted ÷ no. of lines selected) x 100.
§ Rejection % = [no. of lines incorrectly rejected ÷ (no. of lines selected without error + no. of lines incorrectly rejected)] x 100.

Table 14. (Cont.)

Trait and population	Family method							Line method						
	Lines selected	Error						Lines selected	Error					
		None		Acceptance		Rejection			None		Acceptance		Rejection	
	no.	no.	%†	no.	%‡	no.	%§	no.	no.	%†	no.	%‡	no.	%§
Saturates/Linolenate														
AX11056	63	27	43	36	57	6	18	67	29	43	38	57	4	12
AX11063	13	7	54	6	46	15	68	28	12	43	16	57	10	45
AX11080	37	18	49	19	51	12	40	47	22	47	25	53	8	27
AX11104	41	17	41	24	59	4	19	53	20	38	33	62	1	5
Seed Yield														
AX11056	21	21	100	0	0	39	65	37	33	89	4	11	27	45
AX11063	64	58	91	6	9	14	19	65	59	91	6	9	13	18
AX11080	16	11	69	5	31	34	76	30	20	67	10	33	25	56
AX11104	23	14	61	9	39	27	66	32	22	69	10	31	19	46

Table 15. Selection intensity for seed yield required in the plant-row-yield test to recover the highest yielding 10 of 84 F_3-derived lines based on their mean performance across four environments in 1996.

Lines retained†	AX11056	AX11063	AX11080	AX11104	Mean
			%		
1/1	35	2	5	19	15
1/10	10	2	1	2	4
2/10	11	12	5	6	9
3/10	18	20	10	19	17
4/10	20	26	11	20	19
5/10	25	36	16	28	26
6/10	26	37	23	31	29
7/10	32	42	25	32	33
8/10	34	61	26	38	40
9/10	35	62	37	40	44
10/10	83	64	48	50	61

† 1/1 = Highest yielding line; No./10 = Number of the 10 highest yielding lines selected.

Table 16. Selection intensity for seed yield required in one or two replications of the 1996 yield tests to recover the highest yielding 10 of 84 F3-derived lines averaged across four populations.

	Ames			Washington			Bethany			Atlantic			Means	
Lines retained†	Rep 1	Rep 2	Both	Rep 1	Rep 2	Both	Rep 1	Rep 2	Both	Rep 1	Rep 2	Both	Individual Reps	Both Reps
	%													
1/1	12	33	9	21	28	31	9	30	17	12	10	19	19	19
1/10	1	2	2	4	3	3	3	3	5	4	2	2	3	3
2/10	4	3	4	6	7	6	7	5	9	9	5	5	6	6
3/10	8	6	8	10	9	8	10	12	14	12	9	8	10	10
4/10	12	9	11	12	11	10	14	16	17	17	12	14	13	13
5/10	17	19	14	17	16	13	19	20	28	24	25	17	20	18
6/10	24	23	17	26	23	19	23	25	31	27	29	21	25	22
7/10	33	26	29	33	27	26	33	31	39	42	33	27	32	30
8/10	36	42	37	41	35	32	39	39	45	50	41	37	40	38
9/10	44	55	47	55	49	43	54	47	55	58	51	42	52	47
10/10	75	75	57	71	65	69	61	59	63	68	84	67	70	64

† 1/1 = Highest yielding line; No./10 = Number of the 10 highest yielding lines selected.

Table 17. Chi-square analysis of lines selected based on the PRYT in 1995 and one or two replications at individual 1996 locations compared with random selection in four populations.

Population and basis	Lines in 1996 with ≥ 87% yield†	Lines selected‡	Lines selected		[(O - E)^2] / E
			Total (O)§	Random (E)#	
	no.	no.	no.	no.	
PRYT					
AX11056	60	37	33	26	1.63
AX11063	72	65	59	56	0.19
AX11080	45	30	20	16	0.96
AX 11104	41	32	22	16	2.61
Mean	55	41	34	28	X^2 = 5.39 (P = 0.15)
Individual rep					
AX11056	58	51	40	35	0.65
AX11063	71	64	59	54	0.44
AX11080	46	41	33	22	4.96
AX 11104	40	40	28	19	4.21
Mean	54	49	41	32	X^2 = 10.26 (P = 0.01)
Rep mean					
AX11056	58	55	44	38	0.96
AX11063	71	65	61	55	0.67
AX11080	46	41	33	22	4.96
AX 11104	40	39	29	19	5.86
Mean	54	50	42	34	X^2 = 12.43 (P = 0.01)

† Number of lines with ≥ 87% yield of the checks based on their mean performance across locations in 1996 that were not involved in selection.

‡ Total number of lines selected for testing at other locations.

§ Number of lines selected that had ≥ 87% yield based on their mean yield at the other locations.

Number of random expected lines with ≥ 87% yield = [total number of lines selected x (number of lines with ≥ 87% yield in 1996 ÷ 84 lines tested].

Table 18. Phenotypic correlation coefficients of 84 F3-derived lines between the plant-row-yield test and the mean of environments in 1996 for agronomic and seed traits from four soybean populations.

Trait	AX11056	AX11063	AX11080	AX11104
Seed yield (kg ha^{-1})	0.30**	0.43**	0.38**	0.53**
Maturity (days)	0.89**	0.93**	0.93**	0.97**
Height (cm)	0.67**	0.90**	0.86**	0.86**
Lodging (score)	0.52**	0.53**	0.63**	0.42**
Palmitate (g kg^{-1})	0.74**	0.88**	0.22*	0.93**
Stearate (g kg^{-1})	0.36**	0.51**	0.33**	0.31**
Oleate (g kg^{-1})	0.87**	0.85**	0.60**	0.82**
Linoleate (g kg^{-1})	0.88**	0.83**	0.55**	0.86**
Linolenate(g kg^{-1})	0.44**	0.72**	0.50**	0.91**
Saturates (g kg^{-1})	0.37**	0.72**	0.15	0.78**

Table 19. Phenotypic correlation coefficients between test environments for the seed yield of 84 F_3-derived soybean lines in four populations.

	Populations			
Comparison	AX11056	AX11063	AX11080	AX11104
Ames vs. PRYT†	0.26*	0.47**	0.42**	0.47**
Washington vs. PRYT	0.40**	0.38**	0.31**	0.47**
Bethany vs. PRYT	0.04	0.18	0.26*	0.46**
Atlantic vs. PRYT	0.34**	0.53**	0.42**	0.40**
Overall mean‡ vs. PRYT	0.30**	0.43**	0.38**	0.53**
Ames vs. Washington	0.58**	0.74**	0.74**	0.58**
Ames vs. Bethany	0.38**	0.61**	0.72**	0.57**
Ames vs. Atlantic	0.40**	0.82**	0.79**	0.70**
Washington vs. Bethany	0.57**	0.76**	0.84**	0.78**
Washington vs. Atlantic	0.52**	0.78**	0.68**	0.55**
Bethany vs. Atlantic	0.41**	0.59**	0.72**	0.58**
Ames Rep 1 vs. Rest§	0.51**	0.79**	0.80**	0.58**
Ames Rep 2 vs. Rest	0.48**	0.72**	0.75**	0.72**
Ames mean vs. Rest	0.56**	0.81**	0.81**	0.68**
Washington Rep 1 vs. Rest	0.63**	0.85**	0.77**	0.68**
Washington Rep 2 vs. Rest	0.62**	0.76**	0.77**	0.73**
Washington mean vs. Rest	0.73**	0.87**	0.84**	0.75**
Bethany Rep 1 vs. Rest	0.50**	0.63**	0.79**	0.69**
Bethany Rep 2 vs. Rest	0.51**	0.68**	0.79**	0.65**
Bethany mean vs. Rest	0.57**	0.72**	0.84**	0.77**
Atlantic Rep 1 vs. Rest	0.42**	0.74**	0.73**	0.64**
Atlantic Rep 2 vs. Rest	0.47**	0.78**	0.71**	0.56**
Atlantic mean vs. Rest	0.56**	0.81**	0.79**	0.68**

† PRYT = Plant-row-yield tests.
‡ Overall mean = mean of environments in 1996.
§ Rest = mean of the other three environments in 1996.

Table 20. Phenotypic correlation coefficients for population AX11056 based on the mean performance of 84 F_3-derived lines averaged across environments in 1996.

	Maturity	Height	Lodging	Palmitate	Stearate	Oleate	Linoleate	Linolenate	Saturates	Protein	Oil
	days	cm	score	g kg^{-1}							
Seed yield (kg ha^{-1})	0.69**	0.47**	-0.18	0.15	0.06	-0.08	0.05	0.15	0.14	-0.51**	0.06
Maturity (days)		0.70**	-0.34**	-0.07	0.07	-0.25*	0.23*	0.42**	-0.11	-0.74**	-0.28**
Height (cm)			-0.51**	0.16	-0.29**	-0.39**	0.37**	0.43**	-0.09	-0.62**	-0.36**
Lodging (score)				-0.17	-0.22	-0.18	0.21*	-0.13	-0.27*	0.34**	-0.03
Palmitate (g kg^{-1})					-0.03	-0.04	-0.05	0.03	0.71**	-0.10	0.04
Stearate (g kg^{-1})						0.85**	-0.87**	-0.58**	0.66**	0.20	0.57**
Oleate (g kg^{-1})							-0.99**	-0.72**	0.56**	0.37**	0.64**
Linoleate (g kg^{-1})								0.67**	-0.64**	-0.33**	-0.62**
Linolenate(g kg^{-1})									-0.38**	-0.51**	-0.65**
Saturates (g kg^{-1})										0.08	0.42**
Protein (g kg^{-1})											0.27*

Table 21. Phenotypic correlation coefficients for population AX11063 based on the mean performance of 84 F_3-derived lines averaged across environments in 1996.

	Maturity	Height	Lodging	Palmitate	Stearate	Oleate	Linoleate	Linolenate	Saturates	Protein	Oil
	days	cm	score	g kg^{-1}							
Seed yield (kg ha^{-1})	0.70**	0.57**	-0.30**	0.03	-0.34**	-0.57**	0.54**	0.17	-0.10	-0.20	-0.10
Maturity (days)		0.73**	-0.52**	-0.13	-0.31**	-0.86**	0.81**	0.34**	-0.22*	-0.49**	-0.14
Height (cm)			-0.57**	-0.04	-0.42**	-0.66**	0.64**	0.11	-0.21	-0.28**	-0.02
Lodging (score)				0.00	0.25*	0.51**	-0.49**	-0.06	0.09	0.36**	0.07
Palmitate (g kg^{-1})					0.30**	0.21	-0.40**	0.12	0.93**	0.18	-0.11
Stearate (g kg^{-1})						0.38**	-0.48**	-0.02	0.62**	-0.11	-0.01
Oleate (g kg^{-1})							-0.97**	-0.28**	0.31**	0.57**	-0.08
Linoleate (g kg^{-1})								0.12	-0.51**	-0.54**	0.16
Linolenate(g kg^{-1})									0.09	-0.15	-0.49**
Saturates (g kg^{-1})										0.09	-0.09
Protein (g kg^{-1})											-0.29**

Table 22. Phenotypic correlation coefficients for population AX11080 based on the mean performance of 84 F_3-derived lines averaged across environments in 1996.

	Maturity	Height	Lodging	Palmitate	Stearate	Oleate	Linoleate	Linolenate	Saturates	Protein	Oil
	days	cm	score	g kg^{-1}							
Seed yield (kg ha^{-1})	0.69**	0.80**	-0.47**	-0.03	-0.15	-0.47**	0.43**	0.45**	-0.12	-0.32**	-0.31**
Maturity (days)		0.83**	-0.63**	0.10	-0.24*	-0.69**	0.64**	0.63**	-0.24*	-0.46**	-0.62**
Height (cm)			-0.69**	-0.06	-0.23*	-0.59**	0.55**	0.55**	-0.21	-0.43**	-0.48**
Lodging (score)				-0.08	0.07	0.46**	-0.41**	-0.44**	0.04	0.44**	0.32**
Palmitate (g kg^{-1})					0.33**	-0.07	-0.05	-0.03	0.67**	-0.27*	0.19
Stearate (g kg^{-1})						0.52**	-0.64**	-0.26*	0.92**	0.32*	0.19
Oleate (g kg^{-1})							-0.98**	-0.54**	0.38**	0.59**	0.35**
Linoleate (g kg^{-1})								0.44**	-0.53**	-0.56**	-0.31**
Linolenate(g kg^{-1})									-0.25*	-0.33**	-0.64**
Saturates (g kg^{-1})										0.15	0.25*
Protein (g kg^{-1})											0.08

Table 23. Phenotypic correlation coefficients for population AX11104 based on the mean performance of 84 F_3-derived lines averaged across environments in 1996.

	Maturity	Height	Lodging	Palmitate	Stearate	Oleate	Linoleate	Linolenate	Saturates	Protein	Oil
	days	cm	score	g kg^{-1}							
Seed yield (kg ha^{-1})	0.73**	0.71**	-0.51**	0.10	0.01	-0.39**	0.32**	0.06	0.09	-0.16	-0.57**
Maturity (days)		0.80**	-0.77**	0.13	-0.08	-0.69**	0.56**	0.16	0.09	-0.26*	-0.64**
Height (cm)			-0.82**	0.22*	0.02	-0.49**	0.38**	0.08	0.21	-0.13	-0.65**
Lodging (score)				-0.19	0.05	0.59**	-0.46**	-0.14	-0.16	0.30**	0.52**
Palmitate (g kg^{-1})					0.04	-0.18	-0.18	0.49**	0.95**	-0.04	-0.07
Stearate (g kg^{-1})						0.40**	-0.43**	-0.03	0.34**	-0.20	-0.12
Oleate (g kg^{-1})							-0.90**	-0.01	-0.05	0.25*	0.10
Linoleate (g kg^{-1})								-0.39**	-0.29**	-0.28*	0.02
Linolenate(g kg^{-1})									0.44**	0.23*	-0.28*
Saturates (g kg^{-1})										-0.11	-0.09
Protein (g kg^{-1})											-0.08

DISCUSSION

The study indicated that there was no advantage for maintaining family structure in the selection of lines for reduced palmitate, saturates, linolenate, saturates and linolenate, or seed yield. Use of the family method lowered the number of lines selected, did not reduce acceptance error, and increased the rejection error. Our results were similar to those of Bravo et al. (1999) who found that the family method was not more effective than the line method for selection of elevated palmitate in soybean. They indicated that the single-seed-descent (SSD) or bulk methods would be more efficient than the early-generation-testing or pedigree methods for selection of lines with elevated palmitate. The SSD and bulk methods are less expensive to conduct and, require less land, labor, and record keeping than the early-generation-testing or pedigree methods (Fehr, 1987).

Although the development of cultivars with both reduced saturates and linolenate would be possible, combining the two traits would lower the effectiveness of selection compared with that for one of the traits. An additional complication in selecting for the two traits is the development of populations with an acceptable number of segregates To develop the populations for this study, it was necessary to cross lines with the *fan1*(A5) *fan1*(A5) *fan2 fan2 fap1 fap1 fap3 fap3* genotype for reduced saturates and linolenate to a parent with the *fan1*(A5) *fan1*(A5) *fan2 fan2 Fap1 Fap1 Fap3 Fap3* genotype for normal saturates and reduced linolenate or a parent with the *Fan1*(A5) *Fan1*(A5) *Fan2 Fan2 fap1 fap1 fap3 fap3* genotype for reduced saturates and normal linolenate. Crosses of lines with both reduced saturates and linolenate to parents with normal saturates and linolenate were not successful because of the number of major and minor genes that were segregating for the two traits. The inability to use high-yielding conventional genotypes as parents in single-cross populations with parents containing reduced saturates and linolenate would increase the difficulty of developing cultivars with reduced saturates and linolenate that have comparable yield to the conventional ones.

A breeder would like to advance the least percentage of lines from the initial yield evaluation for subsequent testing. The percentage of lines that had to be selected in the PRYT to retain the highest yielding line in the replicated tests ranged from 5 to 35% for the four populations. Byrum (1999)

reported that the selection intensities required in his PRYT to retain the highest yielding line from each of three populations were 16, 38, and 61%.

An average selection intensity of 4% in the PRYT was required to retain one of the 10 highest yielding lines from replicated tests. A similar selection intensity was required for two individual replications or the mean of the two replications at each environment in 1996. The results indicated that unreplicated yield tests can be useful for the initial evaluation of lines . An average of ≈ 20% of the lines in an unreplicated test would have to be selected to retain the highest yielding line. The percentage that has to be selected to retain one or a few of the top lines would average less than 10%.

The difference between correlations for single replications and two replications at each environment in 1996 indicated that the use of replication at testing environments may not be necessary for identifying high-yielding experimental lines. Given fixed resources, reducing the number of replications would allow the breeder the opportunity to evaluate more lines and may contribute to increased genetic gain. Use of PRYT would require less land and seed than replicated tests.

There were differences among the four crosses for the association of reduced-palmitate, saturates, and linolenate with seed yield in lines with the *fan1*(A5) *fan1*(A5) *fan2 fan2 fap1 fap1 fap3 fap3* genotype. The differences among crosses may be due to the genetic background of the parents. The lack of consistency among crosses for the relationship of palmitate and linolenate with agronomic and seed traits also was reported by Ndzana et al. (1994) and Walker et al. (1998). This inconsistency among populations indicated that multiple parents should be utilized in a plant breeding program to insure recovery of cultivars with superior seed yield and agronomic and seed traits. By evaluating lines from multiple populations, it should be possible to develop cultivars with reduced saturates and linolenate that have desirable agronomic and seed traits.

APPENDIX A: MEANS OF LINES AND FAMILIES ACROSS ENVIRONMENTS IN 1996.

Table A1. Mean performance of lines and families across environments in 1996 for population AX11056.

Line or family†	Seed yield	Seed yield	Maturity	Height	Lodging	Palmitate	Stearate	Oleate	Linoleate	Linolenate	Saturatesψ	Protein	Oil
	kg ha^{-1}	% check	days‡	cm	score§	g kg^{-1}							
1 4	2965	89	33	95	4.8	37	32	267	631	33	69	333	159
2 4	3022	91	32	89	6.7	37	32	268	629	34	68	340	152
3 4	3175	95	35	95	5.7	37	31	244	652	37	68	339	157
4 4	3023	91	33	92	5.5	40	32	262	631	35	72	336	162
Family 4 mean	3046	91	33	93	5.7	37	32	260	636	35	69	337	158
1 5	2985	89	32	79	6.0	36	30	244	654	36	66	336	167
2 5	2973	89	33	86	6.2	37	32	235	659	37	69	335	163
3 5	2928	88	31	83	5.7	35	29	232	668	37	64	345	163
4 5	3169	95	33	82	6.0	39	33	235	654	38	72	342	164
Family 5 mean	3014	90	32	82	6.0	37	31	236	659	37	68	339	164
1 6	2837	85	31	89	4.7	37	35	279	615	34	72	348	158
2 6	3034	91	29	83	7.2	38	33	274	622	33	71	347	161
3 6	2910	87	30	88	4.7	37	34	263	630	36	71	342	158
4 6	2829	85	28	83	4.7	37	34	277	618	34	71	342	162
Family 6 mean	2903	87	29	86	5.3	37	34	273	621	34	71	345	160

† Line = first number represents the line within the family and the second number represents the family; family mean = the mean of the four lines within the family.

‡ Days = days after 31 August when 95% of the pods within a plot had reached their mature color.

§ Score = on a scale of 1, all plants prostrate, to 9, all plants erect.

ψ Saturates = palmitate + stearate.

ϖ Check cultivars and lines used to compute % yield.

Table A1. (Cont.)

Line or family†	Seed yield	Seed yield	Maturity	Height	Lodging	Palmitate	Stearate	Oleate	Linoleate	Linolenate	Saturatesψ	Protein	Oil
	kg ha^{-1}	% check	days‡	cm	score§	g kg^{-1}							
1 7	2691	81	31	78	8.0	34	33	268	634	32	67	351	164
2 7	2897	87	32	81	7.5	37	35	260	633	36	72	348	157
3 7	2972	89	31	76	7.5	38	33	276	619	34	71	353	157
4 7	2894	87	30	77	7.7	36	34	271	624	35	70	352	156
Family 7 mean	2864	86	31	78	7.7	36	34	269	627	34	70	351	159
1 8	2955	89	35	85	6.7	36	34	261	635	34	70	340	157
2 8	3458	104	34	85	6.5	37	34	265	629	36	71	342	161
3 8	3130	94	34	88	7.2	37	32	259	638	35	69	345	163
4 8	3408	102	34	84	6.8	37	34	252	642	36	70	348	161
Family 8 mean	3238	97	34	85	6.8	37	33	259	636	35	70	344	161
1 9	3310	99	35	92	6.0	35	28	189	711	38	63	344	162
2 9	2905	87	37	91	6.7	36	30	172	722	41	66	332	141
3 9	3021	91	38	96	6.8	34	29	193	707	38	63	346	148
4 9	2972	89	36	92	6.7	34	29	207	698	32	63	347	157
Family 9 mean	3052	91	36	93	6.5	35	29	190	709	37	64	342	152
1 10	2861	86	31	84	6.2	35	33	282	616	36	67	351	156
2 10	2800	84	31	84	6.5	34	33	291	609	34	67	350	159
3 10	2837	85	32	85	6.2	38	33	264	629	36	70	348	161
4 10	2898	87	32	84	6.5	37	34	266	629	35	71	352	162
Family 10 mean	2849	85	31	84	6.3	36	33	276	621	35	69	350	159

Table A1. (Cont.)

Line or family†	Seed yield	Seed yield	Maturity	Height	Lodging	Palmitate	Stearate	Oleate	Linoleate	Linolenate	Saturates¥	Protein	Oil
	kg ha^{-1}	% check	days‡	cm	score§	g kg^{-1}							
1 11	2586	77	30	89	7.5	32	25	184	718	40	58	348	140
2 11	2668	80	24	80	8.0	37	29	226	674	33	66	359	165
3 11	2061	62	23	78	7.3	37	28	239	662	35	64	354	158
4 11	2658	80	30	88	7.3	35	26	223	681	35	61	354	144
Family 11 mean	2493	75	27	84	7.5	35	27	218	684	36	62	354	152
1 12	3151	94	31	90	6.5	36	31	254	646	34	67	344	156
2 12	3182	95	32	91	6.2	37	31	244	656	33	67	337	158
3 12	3115	93	34	81	7.2	38	33	249	646	33	71	337	154
4 12	3365	101	33	86	7.2	37	31	238	658	35	68	342	156
Family 12 mean	3203	96	33	87	6.8	37	31	246	652	34	68	340	156
1 13	2955	89	35	84	7.5	38	31	242	656	34	69	336	160
2 13	3081	92	34	85	7.3	37	30	244	655	34	67	337	165
3 13	3279	98	33	88	7.3	38	32	246	650	33	70	337	162
4 13	3159	95	33	87	6.5	38	30	242	655	35	68	340	162
Family 13 mean	3118	93	34	86	7.2	38	31	244	654	34	69	337	162
1 14	3227	97	34	84	6.3	35	32	253	645	36	67	340	152
2 14	3321	100	36	84	7.3	36	32	257	642	34	68	342	156
3 14	3255	98	34	84	6.7	36	32	246	653	35	67	344	156
4 14	3136	94	35	86	6.3	36	32	245	650	37	69	345	152
Family 14 mean	3235	97	35	85	6.7	36	32	250	647	35	67	343	154

Table A1. (Cont.)

Line or family†	Seed yield	Seed yield	Maturity	Height	Lodging	Palmitate	Stearate	Oleate	Linoleate	Linolenate	Saturates¥	Protein	Oil
	kg ha^{-1}	% check	days‡	cm	score§	g kg^{-1}							
1 15	3182	95	37	91	5.2	38	31	238	658	36	69	337	157
2 15	3084	92	36	96	5.2	38	31	248	647	36	69	339	157
3 15	3088	93	36	91	5.2	37	31	246	653	34	68	343	154
4 15	3132	94	36	90	4.5	39	31	246	651	35	69	336	163
Family 15 mean	3121	94	36	92	5.0	38	31	244	652	35	69	339	157
1 16	2426	73	19	69	8.2	36	32	257	645	30	68	365	165
2 16	2392	72	19	68	8.3	38	33	270	626	32	71	363	164
3 16	2312	69	19	69	8.3	35	30	243	663	29	65	367	168
4 16	2216	66	20	70	8.2	37	32	235	664	33	69	370	166
Family 16 mean	2336	70	19	69	8.3	37	32	251	650	31	68	366	166
1 17	2802	84	31	89	5.8	36	35	259	635	35	70	349	160
2 17	3134	94	32	84	7.3	35	32	246	651	37	67	341	163
3 17	2887	86	31	86	6.3	35	34	260	637	35	68	340	165
4 17	3180	95	32	89	6.0	36	34	254	642	35	70	336	164
Family 17 mean	3000	90	31	87	6.4	35	34	255	641	35	69	341	163
1 18	3174	95	39	92	6.8	35	29	208	694	36	63	331	157
2 18	3062	92	35	91	7.0	35	28	198	701	38	63	322	157
3 18	3107	93	35	94	7.7	34	28	209	693	36	62	336	161
4 18	2734	82	39	90	6.3	34	29	190	709	39	63	319	145
Family 18 mean	3019	90	37	92	7.0	34	28	201	699	37	63	327	155

Table A1. (Cont.)

Line or family†	Seed yield	Seed yield	Maturity	Height	Lodging	Palmitate	Stearate	Oleate	Linoleate	Linolenate	Saturates¥	Protein	Oil
	kg ha^{-1}	% check	days‡	cm	score§	g kg^{-1}							
1 19	3066	92	31	89	7.5	41	26	184	712	37	67	350	138
2 19	2647	79	32	82	7.7	29	22	161	744	44	51	353	132
3 19	3186	95	30	95	6.3	50	27	184	702	37	77	344	155
4 19	3127	94	29	87	7.5	38	25	198	701	38	63	349	153
Family 19 mean	3006	90	31	88	7.3	39	25	182	714	39	64	349	144
1 20	3270	98	32	86	7.7	36	30	216	686	33	65	334	155
2 20	3118	93	34	91	7.5	36	30	195	701	38	66	333	153
3 20	3364	101	31	85	8.0	38	31	218	680	34	68	340	159
4 20	3061	92	35	86	7.3	33	27	175	726	40	59	329	136
Family 20 mean	3203	96	33	87	7.6	35	29	201	698	36	65	334	151
1 21	3332	100	35	78	7.2	36	31	238	659	37	67	337	161
2 21	3300	99	34	86	7.2	36	31	244	653	36	67	341	164
3 21	3275	98	32	77	7.8	36	32	272	628	32	68	345	167
4 21	3229	97	33	82	8.0	36	31	263	634	36	67	339	167
Family 21 mean	3284	98	33	81	7.5	36	31	254	644	35	67	341	164
1 22	2844	85	34	87	7.8	37	33	265	633	33	70	343	156
2 22	2941	88	34	86	7.5	36	33	260	636	35	70	344	153
3 22	3041	91	34	85	7.0	38	32	245	648	36	71	346	158
4 22	3117	93	34	88	7.2	36	31	234	663	37	66	346	160
Family 22 mean	2986	89	34	86	7.4	37	32	251	645	35	69	345	157

Table A1. (Cont.)

Line or family†	Seed yield	Seed yield	Maturity	Height	Lodging	Palmitate	Stearate	Oleate	Linoleate	Linolenate	Saturatesψ	Protein	Oil
	kg ha^{-1}	% check	days‡	cm	score§	g kg^{-1}							
1 23	2948	88	33	93	6.7	39	25	196	701	40	64	333	157
2 23	2874	86	33	88	6.3	42	29	212	679	38	71	334	141
3 23	3108	93	33	91	6.7	51	27	205	678	39	78	337	151
4 23	2783	83	28	88	6.8	40	26	163	728	43	66	334	141
Family 23 mean	2928	88	32	90	6.6	43	27	194	697	40	70	334	147
1 24	2707	81	28	77	6.7	38	31	285	613	33	69	346	163
2 24	2479	74	28	87	6.2	36	34	299	599	33	70	351	159
3 24	2622	79	29	79	6.0	38	35	291	604	33	72	347	157
4 24	2867	86	37	91	6.5	38	27	173	717	46	65	313	143
Family 24 mean	2669	80	31	84	6.3	37	32	262	633	36	69	339	155
Pioneer 9172ϖ	2952		21	74	8.0	98	37	210	568	87	135	348	179
Pioneer 9281ϖ	3349		27	74	8.0	100	38	223	557	81	138	340	186
Pioneer 9342ϖ	3762		33	88	7.8	103	39	227	543	87	142	352	166
Pioneer 9381ϖ	3737		35	86	7.8	100	41	214	562	83	141	330	176
Pioneer 9243ϖ	3159		24	84	7.3	38	30	216	625	91	68	333	182
YB27Gϖ	3059		28	83	8.0	38	30	199	630	102	69	342	172
YA7343Z006	3178		25	80	7.8	42	32	225	620	81	74	341	185
AX8154A370	3186		28	86	6.7	40	33	213	627	88	73	353	177
XB361ϖ	3372		33	88	8.0	90	44	237	600	29	134	350	164

Table A1. (Cont.)

Line or family†	Seed yield	Seed yield	Maturity	Height	Lodging	Palmitate	Stearate	Oleate	Linoleate	Linolenate	Saturatesψ	Protein	Oil
	kg ha^{-1}	% check	days‡	cm	score§	g kg^{-1}							
Pioneer 9253ϖ	3309		26	86	6.8	103	50	253	566	29	152	340	174
Pioneer 9282ϖ	3252		28	83	7.5	102	38	243	588	30	139	340	168
Pioneer 9322ϖ	3424		30	83	7.0	99	41	220	611	29	140	329	187
CV%	9.2		4.4	5.2	9.7	8.8	8.0	6.9	2.4	10.9	7.1	1.6	3.4
SE	96.5		0.6	1.8	0.3	1.1	0.9	5.8	5.7	1.4	1.7	2.8	2.7
LSD $_{0.05}$	291.7		1.3	4.8	0.7	3.7	2.4	15.9	16.1	3.4	5.2	6.5	7.1
LSD $_{0.01}$	385.0		1.7	6.4	0.9	4.9	3.2	21.0	21.3	4.5	6.9	8.6	9.4

Table A2. Mean performance of lines and families across environments in 1996 for population AX11063.

Line or family†	Seed yield	Seed yield	Maturity	Height	Lodging	Palmitate	Stearate	Oleate	Linoleate	Linolenate	Saturatesψ	Protein	Oil
	kg ha^{-1}	% check	days‡	cm	score§	g kg^{-1}							
1 4	3354	101	36	82	6.8	40	33	233	660	34	73	338	182
2 4	3515	106	37	91	6.2	38	31	214	685	32	69	330	184
3 4	3340	101	36	82	7.3	40	33	226	666	34	73	338	179
4 4	3060	92	38	89	6.8	38	31	212	686	33	69	342	178
Family 4 mean	3317	100	37	86	6.8	39	32	221	674	33	71	337	181
1 5	3308	100	36	91	6.5	39	38	222	663	40	76	331	173
2 5	3157	95	33	80	7.3	38	34	249	639	40	73	339	180
3 5	2920	88	33	82	6.8	51	32	230	635	52	83	338	163
4 5	2125	64	18	70	7.8	37	36	298	598	32	73	354	180
Family 5 mean	2877	87	30	81	7.1	41	35	249	633	41	76	340	174
1 6	2712	82	24	84	8.2	36	33	248	656	27	69	346	199
2 6	3620	109	38	104	6.2	38	34	212	684	33	71	324	189
3 6	3535	107	39	103	6.7	36	33	217	682	32	68	331	194
4 6	3606	109	39	100	6.2	38	32	213	686	31	70	333	182
Family 6 mean	3368	102	35	98	6.8	37	33	223	677	31	69	333	191

† Line = first number represents the line within the family and the second number represents the family; family mean = the mean of the four lines within the family.

‡ Days = days after 31 August when 95% of the pods within a plot had reached their mature color.

§ Score = on a scale of 1, all plants prostrate, to 9, all plants erect.

ψ Saturates = palmitate + stearate.

ϖ Check cultivars and lines used to compute % yield.

Table A2. (Cont.)

Line or family†	Seed yield	Seed yield	Maturity	Height	Lodging	Palmitate	Stearate	Oleate	Linoleate	Linolenate	Saturatesψ	Protein	Oil
	kg ha^{-1}	% check	days‡	cm	score§	g kg^{-1}							
1 7	3113	94	37	76	6.5	40	38	215	673	34	78	321	166
2 7	2690	81	36	80	7.7	38	38	220	658	46	76	319	175
3 7	3005	91	37	81	6.3	38	38	213	668	43	76	317	170
4 7	2872	87	37	79	6.3	37	37	227	667	32	74	320	173
Family 7 mean	2920	88	37	79	6.7	38	38	219	666	39	76	319	171
1 8	3425	103	33	80	7.8	38	36	255	640	32	74	336	176
2 8	3575	108	33	82	7.5	38	33	248	647	35	71	344	180
3 8	3600	109	32	80	7.8	38	34	271	624	33	72	352	177
4 8	3570	108	36	83	7.7	38	35	233	661	33	73	344	178
Family 8 mean	3543	107	33	82	7.7	38	34	252	643	33	72	344	178
1 9	3116	94	36	92	6.3	35	30	234	667	34	65	353	169
2 9	3194	96	37	91	6.8	36	30	228	673	35	65	364	167
3 9	3329	101	37	94	7.0	35	29	221	677	38	64	352	168
4 9	3339	101	37	94	6.8	36	29	224	677	35	65	351	171
Family 9 mean	3244	98	37	93	6.7	35	29	227	673	35	65	355	169
1 10	3085	93	31	81	7.8	56	36	251	626	30	93	346	189
2 10	3256	98	35	93	5.5	44	34	227	662	33	78	345	179
3 10	3293	99	31	92	7.0	48	36	238	645	32	84	345	188
4 10	3450	104	32	84	5.7	51	35	238	642	34	86	349	182
Family 10 mean	3271	99	32	88	6.5	50	35	238	644	32	85	346	184

Table A2. (Cont.)

Line or family†	Seed yield	Seed yield	Maturity	Height	Lodging	Palmitate	Stearate	Oleate	Linoleate	Linolenate	Saturatesψ	Protein	Oil
	kg ha^{-1}	% check	days‡	cm	score§	g kg^{-1}							
1 11	3348	101	35	85	7.5	39	31	227	668	36	69	338	187
2 11	3494	106	36	83	7.0	38	32	241	653	36	70	343	182
3 11	3753	113	35	82	6.5	40	33	233	659	35	73	329	183
4 11	3619	109	34	88	7.2	36	32	259	639	34	68	340	180
Family 11 mean	3554	107	35	85	7.0	38	32	240	655	35	70	337	183
1 12	3120	94	34	85	6.2	38	34	231	667	31	71	327	186
2 12	2877	87	35	85	6.3	39	36	238	656	32	74	318	188
3 12	3276	99	34	88	6.2	37	34	235	660	33	72	324	182
4 12	3228	97	33	83	6.0	36	32	244	655	34	68	327	186
Family 12 mean	3125	94	34	85	6.2	37	34	237	660	32	71	324	185
1 13	3348	101	33	83	6.5	38	31	222	674	35	69	340	174
2 13	3268	99	30	71	8.2	38	33	246	651	33	70	342	185
3 13	3597	109	33	84	7.7	38	32	226	671	32	70	344	179
4 13	3459	104	32	88	7.5	36	31	225	673	34	67	340	173
Family 13 mean	3418	103	32	81	7.5	37	32	230	667	33	69	341	177
1 14	3259	98	34	89	6.3	38	32	220	678	32	70	341	182
2 14	3179	96	35	87	5.2	37	33	217	681	32	70	337	178
3 14	3184	96	35	84	5.3	37	33	214	684	32	70	327	184
4 14	3019	91	35	86	5.7	38	33	218	679	32	71	337	183
Family 14 mean	3160	95	35	87	5.6	38	33	217	681	32	70	336	182

Table A2. (Cont.)

Line or family†	Seed yield	Seed yield	Maturity	Height	Lodging	Palmitate	Stearate	Oleate	Linoleate	Linolenate	Saturatesψ	Protein	Oil
	kg ha^{-1}	% check	days‡	cm	score§	g kg^{-1}							
1 15	3336	101	30	82	6.5	39	34	240	655	32	72	326	181
2 15	3059	92	29	81	6.5	38	31	222	678	32	69	328	185
3 15	3200	97	32	81	6.0	40	34	249	648	29	74	326	180
4 15	2842	86	30	79	6.5	36	32	239	661	31	69	325	189
Family 15 mean	3109	94	30	81	6.4	38	33	237	661	31	71	326	184
1 16	3633	110	33	85	7.5	40	33	242	653	32	73	349	179
2 16	3403	103	32	79	7.0	40	35	242	650	33	76	353	175
3 16	3334	101	33	83	7.3	38	33	245	651	33	71	356	176
4 16	3433	104	32	85	6.3	40	35	253	639	33	75	345	180
Family 16 mean	3451	104	32	83	7.0	39	34	245	648	33	74	351	177
1 17	3098	94	34	88	5.5	38	34	235	660	33	72	342	176
2 17	3166	96	36	84	5.2	38	34	239	656	33	72	335	181
3 17	3211	97	36	88	6.3	37	34	238	658	33	70	347	173
4 17	3103	94	36	90	4.7	37	32	218	679	35	69	335	176
Family 17 mean	3145	95	36	88	5.4	37	33	232	663	34	71	340	176
1 18	2980	90	26	67	7.8	41	34	258	636	31	75	334	189
2 18	2664	80	25	64	8.2	39	36	274	619	33	75	338	185
3 18	2504	76	26	68	8.0	38	36	294	600	31	74	336	178
4 18	3110	94	27	71	7.8	41	37	260	632	31	78	337	179
Family 18 mean	2814	85	26	67	8.0	40	36	272	622	31	75	336	183

Table A2. (Cont.)

Line or family†	Seed yield	Seed yield	Maturity	Height	Lodging	Palmitate	Stearate	Oleate	Linoleate	Linolenate	Saturatesψ	Protein	Oil
	kg ha^{-1}	% check	days‡	cm	score§	g kg^{-1}							
1 19	3285	99	33	101	6.0	39	34	236	658	33	73	350	174
2 19	3267	99	32	95	6.3	39	30	220	679	33	69	342	179
3 19	3683	111	34	95	5.5	38	33	220	675	33	71	344	179
4 19	3361	101	33	98	5.8	39	33	235	659	34	72	340	179
Family 19 mean	3399	103	33	97	5.9	39	32	228	668	33	71	344	178
1 20	2936	89	27	77	7.7	41	37	277	613	32	77	353	172
2 20	2802	85	27	78	8.2	42	36	268	622	33	77	354	182
3 20	2816	85	28	80	7.7	40	37	279	613	32	76	347	171
4 20	2953	89	26	79	8.2	40	36	300	591	32	76	353	169
Family 20 mean	2877	87	27	78	7.9	41	36	281	610	32	77	352	173
1 21	1941	59	23	64	7.8	38	34	278	620	30	72	352	186
2 21	2011	61	23	67	7.7	37	34	289	611	30	71	354	181
3 21	1630	49	19	73	7.3	38	35	315	584	29	72	357	190
4 21	1071	32	21	65	7.7	39	36	294	601	30	75	359	180
Family 21 mean	1663	50	21	67	7.6	38	35	294	604	30	73	356	184
1 22	3280	99	36	85	7.0	38	34	225	671	33	72	344	180
2 22	3303	100	37	91	7.3	37	34	224	671	35	71	338	175
3 22	3138	95	34	74	8.0	38	34	223	671	34	73	335	181
4 22	3076	93	33	81	7.8	40	33	231	661	35	73	350	176
Family 22 mean	3199	97	35	83	7.5	38	34	225	668	34	72	342	178

Table A2. (Cont.)

Line or family†	Seed yield	Seed yield	Maturity	Height	Lodging	Palmitate	Stearate	Oleate	Linoleate	Linolenate	Saturatesψ	Protein	Oil
	kg ha^{-1}	% check	days‡	cm	score§	g kg^{-1}							
1 23	3301	100	39	103	6.7	39	32	204	692	33	71	321	177
2 23	3149	95	39	106	6.2	40	34	215	678	33	74	319	179
3 23	3055	92	38	103	6.7	39	33	206	689	33	72	310	189
4 23	3184	96	39	103	5.3	42	33	208	685	33	75	313	186
Family 23 mean	3172	96	39	104	6.2	40	33	208	686	33	73	316	183
1 24	3198	97	31	86	6.5	52	35	269	610	34	87	354	168
2 24	3190	96	30	86	6.3	36	31	278	619	36	67	347	158
3 24	3148	95	30	87	6.3	53	34	284	594	34	88	354	169
4 24	3233	98	30	81	6.8	53	35	280	598	33	88	351	170
Family 24 mean	3192	96	30	85	6.5	49	34	278	605	34	83	351	166
Pioneer 9172ϖ	2747		21	72	8.3	97	38	213	564	88	135	347	190
Pioneer 9281ϖ	3473		29	74	8.2	99	39	229	551	81	138	340	199
Pioneer 9342ϖ	3742		36	88	7.7	103	40	232	538	87	142	352	175
Pioneer 9381ϖ	3709		36	87	7.7	103	41	205	564	88	143	337	187
Pioneer 9243ϖ	3069		25	82	7.7	38	30	215	627	90	68	341	191
YB27Gϖ	2853		28	78	8.0	33	28	184	641	115	61	344	176
YA7343Z006	3074		26	83	8.2	43	31	216	633	78	73	347	183
AX8154A370	3094		29	88	7.5	37	32	206	632	94	69	358	189
XB361ϖ	3530		34	83	7.8	90	45	244	592	30	134	356	172

Table A2. (Cont.)

Line or family†	Seed yield	Seed yield	Maturity	Height	Lodging	Palmitate	Stearate	Oleate	Linoleate	Linolenate	Saturatesψ	Protein	Oil
	kg ha^{-1}	% check	days‡	cm	score§	g kg^{-1}							
Pioneer 9253ϖ	3221		26	83	7.7	96	50	248	576	30	146	345	179
Pioneer 9282ϖ	3274		29	81	7.7	101	40	250	577	31	141	351	177
Pioneer 9322ϖ	3500		31	83	7.5	105	42	218	607	28	146	328	193
CV%	9.0		4.4	5.6	9.9	7.7	6.5	5.3	2.1	9.2	5.6	1.5	1.8
SE	99.6		0.6	1.9	0.3	1.1	0.8	4.5	4.8	1.1	1.5	2.5	1.6
$LSD_{0.05}$	259.9		1.2	5.3	0.7	3.4	2.2	14.0	14.4	3.4	4.7	8.2	4.2
$LSD_{0.01}$	343.0		1.6	7.0	0.9	4.5	2.8	18.5	19.0	4.5	6.2	10.9	5.5

Table A3. Mean performance of lines and families across environments in 1996 for population AX11080.

Line or family†	Seed yield	Seed yield	Maturity	Height	Lodging	Palmitate	Stearate	Oleate	Linoleate	Linolenate	Saturatesψ	Protein	Oil
	kg ha^{-1}	% check	days‡	cm	score§	g kg^{-1}							
1 4	3270	93	36	80	7.8	40	32	224	669	36	72	328	166
2 4	3248	92	34	83	7.3	37	33	245	651	34	70	333	173
3 4	3004	85	33	82	7.0	38	30	240	655	38	68	323	162
4 4	3052	87	35	77	7.2	36	27	201	698	39	62	315	160
Family 4 mean	3143	89	35	80	7.3	38	30	227	668	37	68	325	165
1 5	2979	85	28	75	8.2	34	27	231	674	33	62	351	165
2 5	2493	71	26	61	8.2	36	27	240	662	35	63	347	166
3 5	2796	80	28	71	8.2	34	27	239	669	31	62	344	167
4 5	2755	78	28	65	8.0	35	28	235	670	33	63	349	170
Family 5 mean	2756	78	27	68	8.1	35	27	236	669	33	62	347	167
1 6	2257	64	20	57	8.3	40	37	247	642	34	77	363	169
2 6	2438	69	19	56	8.5	39	35	271	625	31	74	364	170
3 6	2626	75	21	61	8.3	39	34	262	634	31	73	361	167
4 6	2509	71	21	59	8.5	37	37	268	629	31	73	361	167
Family 6 mean	2458	70	20	58	8.4	39	36	262	632	32	74	362	168

† Line = first number represents the line within the family and the second number represents the family; family mean = the mean of the four lines within the family.

‡ Days = days after 31 August when 95% of the pods within a plot had reached their mature color.

§ Score = on a scale of 1, all plants prostrate, to 9, all plants erect.

ψ Saturates = palmitate + stearate.

ϖ Check cultivars and lines used to compute % yield.

Table A3. (Cont.)

Line or family†	Seed yield	Seed yield	Maturity	Height	Lodging	Palmitate	Stearate	Oleate	Linoleate	Linolenate	Saturates¥	Protein	Oil
	kg ha^{-1}	% check	days‡	cm	score§	g kg^{-1}							
1 7	2288	65	24	59	8.0	37	35	290	610	29	71	350	173
2 7	1889	54	22	54	8.3	34	32	286	616	32	66	349	158
3 7	2066	59	25	59	8.7	36	32	280	625	27	68	349	171
4 7	1913	54	22	52	8.3	37	34	270	628	31	71	353	168
Family 7 mean	2039	58	23	56	8.3	36	33	281	620	30	69	350	167
1 8	2340	67	24	65	8.2	38	29	228	669	36	67	341	160
2 8	2868	82	34	80	7.2	34	38	251	643	35	72	364	161
3 8	2680	76	34	77	7.8	35	40	264	630	33	74	366	159
4 8	2770	79	35	84	6.3	34	38	241	658	30	72	352	168
Family 8 mean	2665	76	32	76	7.4	35	36	246	650	33	71	356	162
1 9	2781	79	38	91	6.7	37	31	204	692	37	67	318	159
2 9	3128	89	37	90	7.3	39	33	219	671	38	72	332	151
3 9	3088	88	38	89	7.7	38	31	208	687	38	68	334	156
4 9	3157	90	39	94	6.0	38	30	208	687	38	68	321	151
Family 9 mean	3038	86	38	91	6.9	38	31	210	684	38	69	326	154
1 10	3574	102	35	85	6.2	39	31	211	684	35	70	344	161
2 10	3049	87	35	84	6.7	38	34	211	681	37	72	344	167
3 10	3378	96	35	85	6.8	38	32	220	676	34	70	338	164
4 10	3109	88	37	84	4.8	40	32	203	685	41	72	328	153
Family 10 mean	3277	93	36	85	6.1	39	32	211	682	37	71	339	161

Table A3. (Cont.)

Line or family†	Seed yield	Seed yield	Maturity	Height	Lodging	Palmitate	Stearate	Oleate	Linoleate	Linolenate	Saturatesψ	Protein	Oil
	kg ha^{-1}	% check	days‡	cm	score§	g kg^{-1}							
1 11	2935	83	26	76	8.2	37	38	295	589	41	75	351	159
2 11	2691	77	26	71	8.2	35	37	288	607	33	72	356	163
3 11	3858	110	33	87	7.3	38	39	242	634	48	77	345	162
4 11	3617	103	37	88	7.0	38	36	233	658	35	74	338	163
Family 11 mean	3275	93	31	80	7.7	37	38	265	622	39	74	347	161
1 12	2994	85	41	85	7.2	37	31	207	686	39	68	336	152
2 12	2675	76	42	83	5.3	37	32	205	687	40	69	334	153
3 12	3080	88	41	88	5.7	37	32	205	687	39	69	344	152
4 12	2935	84	41	84	6.5	36	32	213	681	40	67	339	150
Family 12 mean	2921	83	41	85	6.2	37	32	208	685	40	68	338	152
1 13	3250	92	32	83	7.3	37	30	245	655	33	67	352	170
2 13	2976	85	29	83	8.2	36	30	254	650	31	67	353	166
3 13	2914	83	29	69	8.3	38	30	240	660	32	68	341	174
4 13	3343	95	32	88	7.3	37	30	224	676	33	67	351	161
Family 13 mean	3121	89	30	81	7.8	37	30	241	660	32	67	349	168
1 14	3167	90	33	88	7.2	39	32	203	691	35	71	340	165
2 14	2572	73	30	79	7.8	43	33	215	676	34	76	334	168
3 14	2979	85	33	85	7.3	37	30	195	703	36	67	336	162
4 14	3120	89	30	74	7.7	39	29	198	702	32	68	326	162
Family 14 mean	2959	84	31	82	7.5	39	31	203	693	34	71	334	164

Table A3. (Cont.)

Line or family†	Seed yield	Seed yield	Maturity	Height	Lodging	Palmitate	Stearate	Oleate	Linoleate	Linolenate	Saturatesψ	Protein	Oil
	kg ha^{-1}	% check	days‡	cm	score§	g kg^{-1}							
1 15	2104	60	19	61	8.2	36	30	262	642	30	66	344	184
2 15	2932	83	26	79	6.8	36	29	237	667	31	65	345	175
3 15	3230	92	30	83	6.8	36	28	218	684	33	64	338	180
4 15	3292	94	28	90	6.5	35	27	207	697	35	62	336	173
Family 15 mean	2890	82	26	78	7.1	36	29	231	673	32	64	341	178
1 16	3181	90	39	85	7.7	33	24	189	714	40	57	343	139
2 16	3125	89	36	79	7.8	37	25	206	695	38	62	339	145
3 16	3029	86	38	85	7.7	32	25	209	694	41	56	341	138
4 16	3231	92	39	78	7.8	33	24	191	709	43	58	350	146
Family 16 mean	3141	89	38	82	7.8	34	24	198	703	41	58	343	142
1 17	3143	89	31	75	7.3	36	29	225	677	34	66	336	177
2 17	2946	84	34	77	7.2	37	31	219	679	34	69	334	171
3 17	3271	93	36	85	7.0	39	31	224	672	34	70	327	170
4 17	2653	75	26	74	8.2	35	29	258	646	34	64	338	177
Family 17 mean	3003	85	32	78	7.4	37	30	231	668	34	67	334	174
1 18	3347	95	37	81	7.7	35	28	214	687	36	63	349	167
2 18	3330	95	36	83	8.0	35	29	234	671	32	63	349	164
3 18	3264	93	38	86	7.3	33	28	209	693	38	60	344	160
4 18	3375	96	35	83	7.8	32	29	200	703	36	61	344	166
Family 18 mean	3329	95	36	83	7.7	34	28	214	689	36	62	346	164

Table A3. (Cont.)

Line or family†	Seed yield	Seed yield	Maturity	Height	Lodging	Palmitate	Stearate	Oleate	Linoleate	Linolenate	Saturates¥	Protein	Oil
	kg ha^{-1}	% check	days‡	cm	score§	g kg^{-1}							
1 19	3258	93	36	82	7.2	35	33	247	653	33	67	351	154
2 19	3497	99	34	80	7.3	38	34	261	631	37	72	352	158
3 19	3439	98	34	79	7.2	35	35	261	636	34	70	349	158
4 19	3273	93	34	81	7.7	37	33	264	632	34	71	340	158
Family 19 mean	3367	96	34	80	7.3	36	34	258	638	34	70	348	157
1 20	3460	98	27	86	7.2	37	33	264	634	32	70	349	159
2 20	3253	93	28	73	7.3	34	27	227	676	36	61	337	167
3 20	3010	86	26	81	7.3	34	31	271	632	34	64	349	157
4 20	2305	66	24	65	7.5	36	31	277	625	32	67	348	171
Family 20 mean	3007	86	26	76	7.3	35	30	260	642	33	66	346	163
1 21	3237	92	38	91	6.5	34	30	237	662	38	64	352	141
2 21	3160	90	36	92	7.0	35	32	249	648	36	68	346	150
3 21	3235	92	37	89	6.8	38	32	225	669	38	69	347	145
4 21	3531	100	35	87	7.7	35	30	233	666	36	66	359	159
Family 21 mean	3291	94	36	90	7.0	36	31	236	661	37	67	351	149
1 22	3210	91	35	77	8.2	40	29	211	684	37	68	340	160
2 22	2607	74	32	72	8.3	34	30	228	673	36	64	355	157
3 22	3065	87	35	73	8.5	36	30	223	674	36	66	343	163
4 22	1650	47	20	50	8.7	38	32	243	654	33	70	353	172
Family 22 mean	2633	75	30	68	8.4	37	30	226	671	36	67	348	163

Table A3. (Cont.)

Line or family†	Seed yield	Seed yield	Maturity	Height	Lodging	Palmitate	Stearate	Oleate	Linoleate	Linolenate	Saturates¥	Protein	Oil
	kg ha^{-1}	% check	days‡	cm	score§	g kg^{-1}							
1 23	3213	91	33	75	7.8	38	39	231	660	32	77	335	165
2 23	3278	93	32	74	7.8	37	37	235	662	30	74	334	165
3 23	3230	92	36	81	7.3	37	36	205	687	36	73	333	157
4 23	3204	91	32	75	8.0	38	39	219	671	32	78	342	166
Family 23 mean	3231	92	33	77	7.7	38	38	222	670	33	75	336	163
1 24	3041	87	27	66	7.8	37	39	261	631	32	76	341	176
2 24	2514	72	25	61	8.0	35	39	288	608	31	74	356	164
3 24	2088	59	20	55	8.5	38	39	270	623	30	77	356	169
4 24 mean	2757	78	27	69	8.0	38	37	247	645	33	75	355	166
Family 24	2600	74	25	63	8.1	37	38	266	627	32	75	352	169
Pioneer 9172ϖ	3251		21	70	8.3	97	36	202	573	92	133	348	179
Pioneer 9281ϖ	3700		27	73	8.3	101	39	228	551	81	140	332	192
Pioneer 9342ϖ	3946		34	86	7.8	103	38	227	541	91	141	345	163
Pioneer 9381ϖ	3717		35	84	8.3	101	40	208	566	85	141	332	179
Pioneer 9243ϖ	3277		25	84	7.5	37	30	216	628	90	67	334	182
YB27Gϖ	3051		29	77	7.7	40	30	200	632	98	70	341	169
YA7343Z006	3199		26	82	8.0	46	32	221	623	80	78	341	180
XB26C	3434		27	83	7.8	35	29	199	649	89	64	342	176
XB361ϖ	3690		33	84	8.0	92	46	243	588	30	138	355	165

Table A3. (Cont.)

Line or family†	Seed yield	Seed yield	Maturity	Height	Lodging	Palmitate	Stearate	Oleate	Linoleate	Linolenate	Saturatesψ	Protein	Oil
	kg ha^{-1}	% check	days‡	cm	score§	g kg^{-1}							
Pioneer 9253ϖ	3505		27	80	7.5	100	48	259	565	28	148	344	169
Pioneer 9282ϖ	3364		28	79	7.8	103	38	244	582	33	140	348	169
Pioneer 9322ϖ	3645		30	78	7.3	105	43	216	608	28	147	336	184
CV%	9.3		4.3	6.4	6.4	8.5	8.7	6.8	2.5	11.0	7.6	1.5	3.1
SE	97.8		0.6	2.0	0.2	1.1	1.0	5.6	5.9	1.4	1.8	2.5	2.5
$LSD_{0.05}$	255.8		1.8	5.6	0.6	3.3	2.9	16.5	17.2	3.7	5.3	8.6	7.1
$LSD_{0.01}$	337.6		2.4	7.4	0.8	4.3	3.8	21.8	22.7	4.9	7.0	11.3	9.4

Table A4. Mean performance of lines and families across environments in 1996 for population AX11104.

Line or family†	Seed yield	Seed yield	Maturity	Height	Lodging	Palmitate	Stearate	Oleate	Linoleate	Linolenate	Saturatesψ	Protein	Oil
	kg ha^{-1}	% check	days‡	cm	score§	g kg^{-1}							
1 4	2841	83	26	87	7.2	40	34	244	652	31	73	360	171
2 4	3218	94	29	89	6.7	39	33	230	665	33	73	346	172
3 4	2866	83	28	87	6.8	38	33	248	648	34	71	350	178
4 4	3296	96	33	93	5.8	38	35	232	663	32	74	347	171
Family 4 mean	3055	89	29	89	6.6	39	34	238	657	32	73	351	173
1 5	2864	83	26	81	8.0	37	31	236	664	33	68	368	173
2 5	2939	85	25	82	7.8	40	34	253	639	34	74	367	172
3 5	3125	91	27	80	8.0	37	31	231	667	34	68	372	177
4 5	2650	77	25	75	8.0	39	32	234	663	33	70	370	173
Family 5 mean	2894	84	26	80	8.0	38	32	238	658	34	70	370	174
1 6	1863	54	20	74	7.7	37	32	224	676	31	68	350	192
2 6	2554	74	29	77	7.8	37	33	226	670	34	70	347	175
3 6	3292	96	30	85	7.7	36	31	217	683	34	67	357	170
4 6	2565	75	26	79	7.7	41	33	225	666	35	74	351	180
Family 6 mean	2569	75	26	79	7.7	38	32	223	674	34	70	351	179

† Line = first number represents the line within the family and the second number represents the family; family mean = the mean of the four lines within the family.

‡ Days = days after 31 August when 95% of the pods within a plot had reached their mature color.

§ Score = on a scale of 1, all plants prostrate, to 9, all plants erect.

ψ Saturates = palmitate + stearate.

ϖ Check cultivars and lines used to compute % yield.

Table A4. (Cont.)

Line or family†	Seed yield	Seed yield	Maturity	Height	Lodging	Palmitate	Stearate	Oleate	Linoleate	Linolenate	Saturates¥	Protein	Oil
	kg ha^{-1}	% check	days‡	cm	score§	g kg^{-1}							
1 7	2420	70	30	71	8.0	36	33	238	658	35	69	347	181
2 7	2867	83	30	76	7.8	36	33	223	670	37	69	357	183
3 7	3109	90	29	75	7.7	38	33	234	658	37	71	345	186
4 7	3113	91	36	78	7.5	35	32	220	683	31	66	352	177
Family 7 mean	2877	84	31	75	7.8	36	33	229	667	35	69	350	182
1 8	3264	95	38	95	6.7	38	32	190	704	36	70	352	169
2 8	3328	97	36	89	7.3	39	34	205	687	36	73	362	171
3 8	3038	88	39	97	6.0	36	34	202	694	34	70	351	174
4 8	3194	93	37	91	7.0	36	33	207	692	32	69	354	178
Family 8 mean	3206	93	38	93	6.8	37	33	201	694	34	70	355	173
1 9	2932	85	28	82	8.0	38	35	231	654	42	73	353	181
2 9	2890	84	28	77	7.8	40	37	259	624	40	77	346	174
3 9	3050	89	29	80	8.0	36	34	249	639	42	70	354	169
4 9	3151	92	31	80	7.3	37	35	233	662	33	72	351	173
Family 9 mean	3006	87	29	80	7.8	38	35	243	645	39	73	351	174
1 10	2478	72	25	71	7.5	38	33	224	674	31	71	351	186
2 10	2925	85	39	89	5.8	38	32	194	700	37	70	350	170
3 10	2944	86	39	92	4.5	37	33	197	696	36	70	335	162
4 10	3435	100	35	84	7.3	38	31	195	700	36	69	355	171
Family 10 mean	2945	86	34	84	6.3	38	33	203	692	35	70	348	172

Table A4. (Cont.)

Line or family†	Seed yield	Seed yield	Maturity	Height	Lodging	Palmitate	Stearate	Oleate	Linoleate	Linolenate	Saturatesψ	Protein	Oil
	kg ha^{-1}	% check	days‡	cm	score§	g kg^{-1}							
1 11	2334	68	23	67	7.8	38	33	249	632	48	71	359	180
2 11	2791	81	22	77	8.0	37	32	270	611	51	69	367	174
3 11	2611	76	21	68	7.8	37	31	248	637	47	68	362	182
4 11	2610	76	22	76	7.7	38	32	256	637	37	70	360	179
Family 11 mean	2587	75	22	72	7.8	37	32	256	629	46	69	362	179
1 12	3147	92	38	100	5.8	77	33	198	620	73	109	353	170
2 12	2545	74	22	76	8.0	36	31	260	632	42	67	361	179
3 12	2795	81	26	82	7.5	36	32	255	628	50	67	367	172
4 12	2604	76	24	74	7.7	38	34	252	623	53	72	366	176
Family 12 mean	2772	81	27	83	7.3	47	32	241	626	54	79	361	174
1 13	2952	86	26	85	6.8	37	35	222	675	32	72	346	182
2 13	2679	78	25	80	7.2	37	34	230	669	30	71	355	182
3 13	2727	79	25	80	7.7	35	33	233	668	31	68	358	183
4 13	2826	82	26	80	7.2	37	36	250	648	30	73	358	182
Family 13 mean	2796	81	25	81	7.2	37	34	234	665	31	71	354	182
1 14	3478	101	39	96	5.7	39	31	183	710	38	70	352	169
2 14	3060	89	38	92	6.3	41	32	192	696	39	73	355	173
3 14	3085	90	40	96	5.5	36	30	189	706	39	66	367	165
4 14	2841	83	39	94	6.0	38	33	197	694	39	71	367	156
Family 14 mean	3116	91	39	94	5.9	38	32	190	702	39	70	360	166

Table A4. (Cont.)

Line or family†	Seed yield	Seed yield	Maturity	Height	Lodging	Palmitate	Stearate	Oleate	Linoleate	Linolenate	Saturatesψ	Protein	Oil
	kg ha^{-1}	% check	days‡	cm	score§	g kg^{-1}							
1 15	3207	93	29	81	7.5	38	35	256	639	33	73	347	169
2 15	2548	74	27	79	7.5	38	36	278	611	38	74	354	165
3 15	2773	81	27	76	8.0	37	36	258	631	39	72	353	169
4 15	2776	81	28	75	7.8	36	35	256	627	46	71	350	169
Family 15 mean	2826	82	28	78	7.7	37	35	262	627	39	72	351	168
1 16	3017	88	26	82	7.5	39	33	212	671	45	72	361	182
2 16	2571	75	26	79	6.8	43	33	220	657	49	76	358	180
3 16	2699	79	27	79	7.5	37	33	224	661	45	70	365	175
4 16	2845	83	28	76	7.5	39	32	216	664	51	70	366	179
Family 16 mean	2783	81	27	79	7.3	39	33	218	663	47	72	363	179
1 17	3227	94	36	88	6.5	40	32	198	694	36	72	346	179
2 17	2111	61	20	62	7.7	38	30	210	690	33	68	349	197
3 17	3288	96	32	78	7.0	39	32	206	691	34	70	347	184
4 17	3001	87	25	76	7.2	38	31	210	687	35	69	350	184
Family 17 mean	2907	85	28	76	7.1	38	31	206	690	34	70	348	186
1 18	2389	69	22	71	7.7	38	33	234	665	30	72	349	194
2 18	2098	61	20	72	7.3	40	33	228	670	29	73	347	189
3 18	3509	102	31	91	6.5	40	34	217	676	32	74	344	179
4 18	2220	65	23	78	7.5	37	34	220	679	30	72	356	196
Family 18 mean	2554	74	24	78	7.3	39	34	225	672	30	73	349	190

Table A4. (Cont.)

Line or family†	Seed yield	Seed yield	Maturity	Height	Lodging	Palmitate	Stearate	Oleate	Linoleate	Linolenate	Saturatesψ	Protein	Oil
	kg ha^{-1}	% check	days‡	cm	score§	g kg^{-1}							
1 19	3036	88	34	96	6.8	38	33	213	679	38	71	364	173
2 19	3054	89	34	93	6.7	38	33	222	672	36	71	367	174
3 19	2723	79	25	87	7.2	37	33	234	663	34	70	361	181
4 19	3232	94	35	95	5.8	39	32	204	689	36	71	361	180
Family 19 mean	3011	88	32	93	6.6	38	33	218	676	36	71	363	177
1 20	3027	88	28	90	7.3	38	33	263	636	30	71	362	169
2 20	3173	92	33	97	5.7	39	33	230	665	34	72	361	165
3 20	3157	92	33	94	6.5	41	33	223	665	39	74	352	165
4 20	2889	84	32	89	6.5	39	33	238	656	35	72	357	166
Family 20 mean	3061	89	32	93	6.5	39	33	238	655	34	72	358	166
1 21	2844	83	34	82	7.0	40	30	205	690	35	70	350	176
2 21	3271	95	41	99	6.2	35	32	192	704	37	67	335	168
3 21	3223	94	37	84	6.8	37	33	206	689	35	71	340	178
4 21	3084	90	41	93	6.0	36	32	190	707	37	67	341	173
Family 21 mean	3106	90	38	90	6.5	37	32	198	697	36	69	341	174
1 22	3092	90	34	88	6.8	44	33	211	677	36	77	335	176
2 22	3387	99	33	93	6.0	39	34	220	671	36	72	334	169
3 22	2998	87	34	101	5.2	37	33	235	662	34	69	347	168
4 22	3187	93	33	94	6.2	38	34	223	672	34	72	336	173
Family 22 mean	3166	92	33	94	6.0	39	33	223	670	35	73	338	171

Table A4. (Cont.)

Line or family†	Seed yield	Seed yield	Maturity	Height	Lodging	Palmitate	Stearate	Oleate	Linoleate	Linolenate	Saturatesψ	Protein	Oil
	kg ha^{-1}	% check	days‡	cm	score§	g kg^{-1}							
1 23	2543	74	21	80	7.8	38	33	249	651	31	70	352	187
2 23	2626	76	22	74	8.0	36	30	246	657	32	66	347	182
3 23	2710	79	24	79	8.0	36	32	239	660	32	68	357	183
4 23	2734	80	23	79	7.8	38	35	249	648	30	73	351	182
Family 23 mean	2653	77	22	78	7.9	37	32	246	654	31	69	352	183
1 24	3110	90	39	91	5.3	37	33	207	668	55	70	355	169
2 24	3348	97	34	90	6.5	38	32	241	657	33	69	361	173
3 24	3188	93	36	91	6.2	36	33	234	645	51	69	352	173
4 24	3073	89	38	94	5.5	36	33	224	657	51	68	355	163
Family 24 mean	3180	92	37	91	5.9	37	33	226	657	48	69	356	169
Pioneer 9172ϖ	2913		21	77	7.8	97	36	202	573	92	133	345	188
Pioneer 9281ϖ	3509		28	77	8.0	101	39	230	549	81	140	340	198
Pioneer 9342ϖ	3801		34	90	7.7	104	40	229	537	90	144	351	174
Pioneer 9381ϖ	3812		36	89	7.5	102	42	213	556	86	144	338	186
Pioneer 9243ϖ	3171		25	86	7.5	36	30	213	631	90	66	338	193
YB27Gϖ	3021		30	77	7.8	39	31	198	630	102	70	344	174
AX8154A370	3273		29	87	6.8	35	31	204	637	93	66	358	189
XB26C	3201		27	84	7.8	36	30	203	643	88	67	354	180
XB36Iϖ	3663		33	88	7.8	89	44	244	594	29	133	361	172

Table A4. (Cont.)

Line or family†	Seed yield	Seed yield	Maturity	Height	Lodging	Palmitate	Stearate	Oleate	Linoleate	Linolenate	Saturatesψ	Protein	Oil
	kg ha^{-1}	% check	days‡	cm	score§	g kg^{-1}							
Pioneer 9253ϖ	3303		26	82	6.8	99	51	264	556	30	150	352	180
Pioneer 9282ϖ	3558		28	82	7.8	103	39	252	574	32	142	354	176
Pioneer 9322ϖ	3630		31	83	7.0	104	43	214	610	29	147	341	190
CV%	9.0		5.2	5.1	6.7	8.0	6.8	5.3	1.9	9.5	6.1	1.1	1.7
SE	92.0		0.6	1.7	0.2	1.1	0.8	4.2	4.6	1.2	1.5	2.0	1.5
LSD $_{0.05}$	265.0		1.9	5.2	0.9	3.3	2.2	14.8	15.9	3.4	4.8	6.4	4.6
LSD $_{0.01}$	349.7		2.6	6.9	1.2	4.3	2.9	19.5	21.0	4.5	6.4	8.4	6.1

APPENDIX B: MEANS OF LINES AND FAMILIES FROM THE PLANT-ROW-YIELD TEST.

Table B1. Performance of lines and families in the plant-row-yield test in 1995 for population AX11056.

Line or family†	Seed yield	Seed yield	Maturity	Height	Lodging	Palmitate	Stearate	Oleate	Linoleate	Linolenate	Saturatesψ
	kg ha^{-1}	% check	days‡	cm	score§	g kg^{-1}					
1 4	3150	88	36	97	5	40	32	325	574	29	72
2 4	3191	89	36	92	6	38	33	318	583	28	71
3 4	3723	104	36	103	7	37	32	282	622	27	69
4 4	2086	58	38	108	2	36	32	320	585	28	68
Family 4 mean	3038	85	37	100	5	38	32	311	591	28	70
1 5	2741	76	39	92	7	37	29	284	618	32	66
2 5	4009	112	36	103	7	39	31	302	596	31	70
3 5	2741	76	40	92	7	36	29	292	611	32	65
4 5	2864	80	37	97	7	36	32	259	638	34	68
Family 5 mean	3089	86	38	96	7	37	30	284	616	32	67
1 6	2455	68	33	97	2	34	28	325	584	28	62
2 6	3764	105	33	92	8	36	29	322	585	27	65
3 6	2455	68	34	92	4	35	29	325	582	29	64
4 6	3436	96	33	92	7	36	28	364	547	26	64
Family 6 mean	3027	84	33	94	5	35	29	334	575	28	64

† Line = first number represents the line within the family and the second number represents the family; family mean = the mean of the four lines within the family.

‡ Days = days after 31 August when 95% of the pods within a plot had reached their mature color.

§ Score = on a scale of 1, all plants prostrate, to 9, all plants erect.

ψ Saturates = palmitate + stearate.

ϖ Check cultivars and lines used to compute % yield.

Table B1. (Cont.)

Line or family†	Seed yield	Seed yield	Maturity	Height	Lodging	Palmitate	Stearate	Oleate	Linoleate	Linolenate	Saturatesψ
	kg ha^{-1}	% check	days‡	cm	score§	g kg^{-1}					
1 7	3068	86	33	92	8	36	31	355	552	25	67
2 7	2986	83	34	92	7	37	31	329	576	27	68
3 7	3927	110	32	87	8	38	31	342	563	27	69
4 7	2986	83	32	87	7	35	28	335	575	27	63
Family 7 mean	3242	90	33	90	8	37	30	340	567	27	67
1 8	2250	63	36	103	7	38	34	328	570	29	72
2 8	3682	103	36	97	7	40	30	329	570	31	70
3 8	3600	100	34	97	8	38	31	297	605	29	69
4 8	3232	90	34	97	7	36	31	306	596	31	67
Family 8 mean	3191	89	35	99	7	38	32	315	585	30	70
1 9	2577	72	38	113	6	39	29	252	655	26	68
2 9	2577	72	42	108	8	33	29	216	688	33	62
3 9	2373	66	44	118	7	37	31	207	684	40	68
4 9	3232	90	40	113	7	37	32	229	670	31	69
Family 9 mean	2690	75	41	113	7	37	30	226	674	33	67
1 10	2905	81	35	92	7	34	30	356	552	28	64
2 10	3068	86	34	92	6	35	26	342	569	28	61
3 10	2782	78	35	103	7	34	27	348	563	27	61
4 10	3314	92	33	92	6	38	32	340	564	25	70
Family 10 mean	3017	84	34	95	7	35	29	347	562	27	64

Table B1. (Cont.)

Line or family†	Seed yield	Seed yield	Maturity	Height	Lodging	Palmitate	Stearate	Oleate	Linoleate	Linolenate	Saturatesψ
	kg ha^{-1}	% check	days‡	cm	score§	g kg^{-1}					
1 11	2864	80	30	92	6	33	26	251	659	32	59
2 11	3845	107	22	92	8	36	27	325	589	24	63
3 11	2577	72	20	82	7	34	22	328	588	27	56
4 11	2086	58	33	103	6	32	26	255	657	30	58
Family 11 mean	2843	79	26	92	7	34	25	290	623	28	59
1 12	2782	78	36	108	6	37	30	332	574	27	67
2 12	3068	86	36	97	5	35	27	267	641	31	62
3 12	3600	100	36	92	7	37	31	307	599	25	68
4 12	3559	99	36	97	7	35	30	284	621	31	65
Family 12 mean	3252	91	36	99	6	36	30	298	609	29	66
1 13	1923	54	33	87	5	44	32	322	568	33	76
2 13	2618	73	36	97	7	37	28	313	591	31	65
3 13	3355	94	34	97	6	39	32	318	585	26	71
4 13	2864	80	33	92	6	38	30	308	598	26	68
Family 13 mean	2690	75	34	94	6	40	31	315	586	29	70
1 14	3109	87	36	103	8	37	30	306	598	28	67
2 14	3355	94	36	103	8	39	29	309	594	28	68
3 14	2986	83	36	108	8	38	31	318	586	27	69
4 14	3355	94	39	103	8	37	34	315	588	26	71
Family 14 mean	3201	89	37	104	8	38	31	312	592	27	69

Table B1. (Cont.)

Line or family†	Seed yield	Seed yield	Maturity	Height	Lodging	Palmitate	Stearate	Oleate	Linoleate	Linolenate	Saturates¥
	kg ha^{-1}	% check	days‡	cm	score§	g kg^{-1}					
1 15	3886	108	38	108	6	38	27	272	634	28	65
2 15	2945	82	42	92	5	35	28	281	623	32	63
3 15	2659	74	39	97	6	36	30	292	611	30	66
4 15	3191	89	38	108	7	40	28	276	629	27	68
Family 15 mean	3170	88	39	101	6	37	28	280	624	29	66
1 16	2986	83	16	82	7	34	25	329	586	27	59
2 16	2945	82	17	77	7	34	23	345	573	24	57
3 16	2986	83	16	82	7	32	24	376	547	21	56
4 16	2823	79	16	82	7	35	25	311	605	24	60
Family 16 mean	2935	82	16	81	7	34	24	340	578	24	58
1 17	2986	83	34	97	6	38	35	304	588	35	73
2 17	3518	98	33	92	8	36	31	304	600	28	67
3 17	3027	84	35	97	8	35	27	329	580	28	62
4 17	2577	72	36	92	6	37	32	308	595	27	69
Family 17 mean	3027	84	35	95	7	37	31	311	591	30	68
1 18	2782	78	42	113	8	35	28	243	662	32	63
2 18	2414	67	42	113	7	37	31	248	654	30	68
3 18	2905	81	39	113	7	37	27	233	669	32	64
4 18	2741	76	43	118	8	38	33	225	673	31	71
Family 18 mean	2710	76	42	114	8	37	30	237	665	31	67

Table B1. (Cont.)

Line or family†	Seed yield	Seed yield	Maturity	Height	Lodging	Palmitate	Stearate	Oleate	Linoleate	Linolenate	Saturatesψ
	kg ha^{-1}	% check	days‡	cm	score§	g kg^{-1}					
1 19	3641	102	32	97	8	50	30	231	659	29	80
2 19	2741	76	32	92	8	33	27	254	656	30	60
3 19	3805	106	32	103	7	57	29	219	666	29	86
4 19	3641	102	32	97	8	50	27	265	629	28	77
Family 19 mean	3457	96	32	97	8	48	28	242	653	29	76
1 20	3273	91	36	103	7	36	33	260	644	26	69
2 20	3559	99	37	103	8	37	30	219	684	30	67
3 20	3355	94	34	103	8	38	32	267	636	27	70
4 20	3477	97	38	113	7	36	29	215	687	33	65
Family 20 mean	3416	95	36	105	8	37	31	240	663	29	68
1 21	3273	91	36	97	8	37	27	300	604	31	64
2 21	3682	103	36	92	8	37	29	306	603	25	66
3 21	2700	75	32	92	7	40	30	320	580	29	70
4 21	3518	98	36	92	8	37	30	289	615	29	67
Family 21 mean	3293	92	35	94	8	38	29	304	601	29	67
1 22	3314	92	38	97	8	38	28	300	604	30	66
2 22	2782	78	38	97	8	35	32	329	575	29	67
3 22	3641	102	40	103	8	35	30	292	613	30	65
4 22	2495	70	37	97	7	34	30	312	590	34	64
Family 22 mean	3058	85	38	99	8	36	30	308	596	31	66

Table B1. (Cont.)

Line or family†	Seed yield	Seed yield	Maturity	Height	Lodging	Palmitate	Stearate	Oleate	Linoleate	Linolenate	Saturatesψ
	kg ha^{-1}	% check	days‡	cm	score§	g kg^{-1}					
1 23	3109	87	34	108	6	47	27	241	653	31	74
2 23	2823	79	35	108	8	47	27	277	624	25	74
3 23	3232	90	34	108	6	52	28	301	594	24	80
4 23	3232	90	29	97	7	44	26	236	665	28	70
Family 23 mean	3099	86	33	105	7	48	27	264	634	27	75
1 24	3068	86	24	82	7	37	30	362	544	27	67
2 24	2782	78	32	82	6	35	34	384	518	29	69
3 24	2945	82	26	92	7	39	33	344	561	23	72
4 24	2659	74	27	82	7	43	31	204	687	34	74
Family 24 mean	2864	80	27	85	7	39	32	324	578	28	71
Pioneer 9172ϖ	3191		20	82	7	96	32	219	576	77	128
Pioneer 9281ϖ	3968		24	82	8	104	36	245	545	69	140
Pioneer 9342ϖ	3723		39	103	8	108	38	241	532	81	146
Pioneer 9381ϖ	3845		37	103	8	105	42	225	552	76	147
Pioneer 9243ϖ	3600		22	92	7	36	26	228	632	78	62
YB27Gϖ	3068		25	87	8	36	27	220	625	92	63
YA7343Z006	3805		26	92	7	36	28	257	607	72	64
AX8154A370	.		.	.	.	.	.	.	.	.	.
XB361ϖ	3559		34	103	7	94	40	252	591	22	134

Table B1. (Cont.)

Line or family†	Seed yield	Seed yield	Maturity	Height	Lodging	Palmitate	Stearate	Oleate	Linoleate	Linolenate	Saturatesψ
	kg ha^{-1}	% check	days‡	cm	score§	g kg^{-1}					
Pioneer 9253ϖ	3805		24	97	7	107	42	337	493	21	149
Pioneer 9282ϖ	3641		30	92	8	109	37	289	535	29	146
Pioneer 9322ϖ	3436		32	92	7	112	39	239	585	24	151

Table B2. Performance of lines and families in the plant-row-yield test in 1995 for population AX11063.

Line or family†	Seed yield	Seed yield	Maturity	Height	Lodging	Palmitate	Stearate	Oleate	Linoleate	Linolenate	Saturatesψ
	kg ha^{-1}	% check	days‡	cm	score§	g kg^{-1}					
1 4	2986	100	34	92	8	37	37	299	597	30	74
2 4	3600	121	34	108	7	34	33	268	639	25	67
3 4	3027	101	36	92	7	38	36	283	617	27	74
4 4	1841	62	35	103	7	36	34	263	639	29	70
Family 4 mean	2864	96	35	99	7	36	35	278	623	28	71
1 5	3150	105	34	97	5	40	44	298	583	34	84
2 5	3232	108	33	92	5	39	36	306	588	30	75
3 5	3436	115	34	92	2	49	37	312	566	35	86
4 5	3027	101	18	82	6	32	35	452	457	24	67
Family 5 mean	3211	108	30	91	5	40	38	342	549	31	78
1 6	2986	100	17	92	7	35	31	373	538	22	66
2 6	3355	112	36	118	6	36	40	298	601	25	76
3 6	3068	103	42	113	6	34	33	265	638	29	67
4 6	3109	104	42	118	7	36	37	257	642	28	73
Family 6 mean	3130	105	34	110	7	35	35	298	605	26	71

† Line = first number represents the line within the family and the second number represents the family; family mean = the mean of the four lines within the family.

‡ Days = days after 31 August when 95% of the pods within a plot had reached their mature color.

§ Score = on a scale of 1, all plants prostrate, to 9, all plants erect.

ψ Saturates = palmitate + stearate.

ϖ Check cultivars and lines used to compute % yield.

Table B2. (Cont.)

Line or family†	Seed yield	Seed yield	Maturity	Height	Lodging	Palmitate	Stearate	Oleate	Linoleate	Linolenate	Saturatesψ
	kg ha^{-1}	% check	days‡	cm	score§	g kg^{-1}					
1 7	2127	71	35	92	8	37	46	273	616	28	83
2 7	1800	60	34	92	8	34	46	292	594	33	80
3 7	2332	78	36	97	7	35	46	274	610	34	81
4 7	2700	90	36	97	7	37	44	290	604	26	81
Family 7 mean	2240	75	35	95	8	36	46	282	606	30	81
1 8	2659	89	34	97	8	36	40	332	568	25	76
2 8	2945	99	31	97	8	35	35	293	609	27	70
3 8	3559	119	33	97	8	34	35	316	587	28	69
4 8	2905	97	35	97	7	38	39	288	608	27	77
Family 8 mean	3017	101	33	97	8	36	37	307	593	27	73
1 9	2005	67	36	103	7	34	34	277	626	29	68
2 9	2823	95	36	103	7	34	33	284	618	30	67
3 9	3232	108	37	97	6	35	38	312	587	27	73
4 9	3027	101	36	108	7	34	34	292	612	28	68
Family 9 mean	2772	93	36	103	7	34	35	291	611	29	69
1 10	3191	107	27	92	7	55	35	279	602	28	90
2 10	2986	100	32	103	6	40	41	292	598	28	81
3 10	3109	104	23	108	7	34	36	302	601	26	70
4 10	2577	86	29	92	6	48	37	280	609	25	85
Family 10 mean	2966	99	28	99	7	44	37	288	603	27	82

Table B2. (Cont.)

Line or family†	Seed yield	Seed yield	Maturity	Height	Lodging	Palmitate	Stearate	Oleate	Linoleate	Linolenate	Saturatesψ
	kg ha^{-1}	% check	days‡	cm	score§	g kg^{-1}					
1 11	3723	125	33	97	7	35	33	271	632	30	68
2 11	2823	95	36	97	7	36	36	292	607	29	72
3 11	4050	136	33	87	7	37	37	284	613	29	74
4 11	3109	104	35	87	7	36	34	319	582	29	70
Family 11 mean	3426	115	34	92	7	36	35	292	609	29	71
1 12	3355	112	33	92	6	35	46	334	560	24	81
2 12	1595	53	33	92	4	33	45	347	549	26	78
3 12	3068	103	33	92	6	34	39	282	616	28	73
4 12	3109	104	32	92	7	34	38	349	554	24	72
Family 12 mean	2782	93	33	92	6	34	42	328	570	26	76
1 13	3600	121	33	97	8	36	37	306	592	29	73
2 13	3477	116	28	82	8	36	38	310	587	29	74
3 13	3068	103	32	97	7	35	36	275	627	27	71
4 13	3641	122	29	97	7	36	37	306	590	29	73
Family 13 mean	3447	115	31	94	8	36	37	299	599	29	73
1 14	2536	85	33	92	6	36	40	347	551	27	76
2 14	3436	115	35	103	7	37	33	254	651	26	70
3 14	2659	89	32	92	6	34	33	273	635	24	67
4 14	3355	112	35	92	6	35	33	276	633	24	68
Family 14 mean	2997	100	34	95	6	36	35	288	618	25	70

Table B2. (Cont.)

Line or family†	Seed yield	Seed yield	Maturity	Height	Lodging	Palmitate	Stearate	Oleate	Linoleate	Linolenate	Saturatesψ
	kg ha^{-1}	% check	days‡	cm	score§	g kg^{-1}					
1 15	3150	105	27	87	7	31	39	334	571	25	70
2 15	3600	121	29	92	6	34	34	314	590	27	68
3 15	2495	84	31	87	5	34	40	311	589	25	74
4 15	2700	90	28	82	5	33	33	292	617	24	66
Family 15 mean	2986	100	29	87	6	33	37	313	592	25	70
1 16	2945	99	31	92	7	34	35	357	547	26	69
2 16	3191	107	27	82	8	36	36	294	606	27	72
3 16	3109	104	32	92	8	35	38	301	598	27	73
4 16	2986	100	32	87	6	35	39	299	596	31	74
Family 16 mean	3058	102	31	88	7	35	37	313	587	28	72
1 17	2332	78	33	97	7	37	39	314	583	27	76
2 17	2536	85	34	92	5	36	38	316	583	27	74
3 17	3273	110	33	97	6	36	35	327	577	30	71
4 17	3068	103	34	92	6	36	37	323	580	24	73
Family 17 mean	2802	94	34	95	6	36	37	320	581	27	74
1 18	3764	126	26	77	7	36	32	332	575	25	68
2 18	2823	95	26	77	8	34	37	367	534	28	71
3 18	3314	111	26	82	8	35	41	391	506	26	76
4 18	4214	141	26	82	8	35	41	361	535	27	76
Family 18 mean	3528	118	26	79	8	35	38	363	538	27	73

Table B2. (Cont.)

Line or family†	Seed yield	Seed yield	Maturity	Height	Lodging	Palmitate	Stearate	Oleate	Linoleate	Linolenate	Saturatesψ
	kg ha^{-1}	% check	days‡	cm	score§	g kg^{-1}					
1 19	3027	101	33	113	5	34	37	312	590	25	71
2 19	3232	108	32	108	3	35	37	305	596	27	72
3 19	3232	108	32	103	4	35	34	274	630	27	69
4 19	2659	89	33	103	5	36	38	324	578	24	74
Family 19 mean	3038	102	33	106	4	35	37	304	599	26	72
1 20	3027	101	24	82	8	40	40	358	534	27	80
2 20	2495	84	20	82	7	37	37	347	551	28	74
3 20	3518	118	23	82	8	38	40	357	539	26	78
4 20	3436	115	24	87	8	36	42	444	454	24	78
Family 20 mean	3119	104	23	83	8	38	40	377	520	26	78
1 21	1759	59	16	72	8	34	31	395	516	25	65
2 21	2455	82	16	67	7	32	33	452	461	21	65
3 21	2086	70	18	82	7	32	31	452	464	21	63
4 21	2045	68	17	67	7	33	28	457	460	21	61
Family 21 mean	2086	70	17	72	7	33	31	439	475	22	64
1 22	3068	103	36	103	7	33	37	283	619	29	70
2 22	3518	118	37	108	7	37	39	279	617	27	76
3 22	2332	78	35	87	7	35	38	293	610	25	73
4 22	2659	89	35	92	8	36	35	279	626	25	71
Family 22 mean	2894	97	36	97	7	35	37	284	618	27	73

Table B2. (Cont.)

Line or family†	Seed yield	Seed yield	Maturity	Height	Lodging	Palmitate	Stearate	Oleate	Linoleate	Linolenate	Saturatesψ
	kg ha^{-1}	% check	days‡	cm	score§	g kg^{-1}					
1 23	2823	95	43	118	6	36	37	250	650	26	73
2 23	2291	77	42	123	5	38	39	266	629	27	77
3 23	2986	100	41	128	6	37	40	273	622	28	77
4 23	3600	121	36	113	5	38	37	251	647	27	75
Family 23 mean	2925	98	41	121	6	37	38	260	637	27	76
1 24	2905	97	28	97	8	54	35	327	558	26	89
2 24	2455	82	29	87	6	34	29	361	548	29	63
3 24	2986	100	25	87	6	54	31	347	540	27	85
4 24	2864	96	26	87	6	55	37	347	533	26	92
Family 24 mean	2802	94	27	90	7	49	33	346	545	27	82
Pioneer 9172ϖ	2864		18	82	8	98	37	238	550	76	135
Pioneer 9281ϖ	2945		23	82	8	98	38	268	528	66	136
Pioneer 9342ϖ	3395		30	103	8	113	42	238	523	83	155
Pioneer 9381ϖ	3395		33	103	8	107	45	237	540	70	152
Pioneer 9243ϖ	2536		18	87	6	33	30	276	588	72	63
YB27Gϖ	2332		22	87	6	32	30	259	596	82	62
YA7343Z006	.		.	.	.	.	.	.	.	.	.
AX8154A370	3355		23	92	6	33	30	255	607	76	63
XB361ϖ	3477		28	97	7	97	45	288	546	23	142

Table B2. (Cont.)

Line or family†	Seed yield	Seed yield	Maturity	Height	Lodging	Palmitate	Stearate	Oleate	Linoleate	Linolenate	Saturatesψ
	kg ha^{-1}	% check	days‡	cm	score§	g kg^{-1}					
Pioneer 9253ϖ	2741		20	103	7	105	56	327	485	26	161
Pioneer 9282ϖ	3150		21	92	8	104	39	341	488	27	143
Pioneer 9322ϖ	3027		24	92	7	106	44	224	597	28	150

Table B3. Performance of lines and families in the plant-row-yield test in 1995 for population AX11080.

Line or family†	Seed yield	Seed yield	Maturity	Height	Lodging	Palmitate	Stearate	Oleate	Linoleate	Linolenate	Saturatesψ
	kg ha^{-1}	% check	days‡	cm	score§	g kg^{-1}					
1 4	3436	92	42	103	8	40	37	267	623	32	77
2 4	1882	51	38	92	7	37	35	337	563	28	72
3 4	1923	52	42	92	7	37	32	295	602	33	69
4 4	3027	81	43	92	7	39	32	265	633	30	71
Family 4 mean	2567	69	41	95	7	38	34	291	605	31	72
1 5	3436	92	30	87	8	35	29	294	613	28	64
2 5	2455	66	27	82	8	36	28	369	543	25	64
3 5	3027	81	30	87	7	36	31	364	543	27	67
4 5	2700	73	28	82	8	42	44	239	645	30	86
Family 5 mean	2905	78	29	85	8	37	33	317	586	28	70
1 6	3109	84	19	72	7	37	33	321	585	23	70
2 6	2864	77	19	67	8	38	28	367	544	23	66
3 6	2945	79	19	72	7	38	29	331	579	24	67
4 6	3968	107	19	72	8	36	36	382	521	24	72
Family 6 mean	3222	87	19	71	8	37	32	350	557	24	69

† Line = first number represents the line within the family and the second number represents the family; family mean = the mean of the four lines within the family.

‡ Days = days after 31 August when 95% of the pods within a plot had reached their mature color.

§ Score = on a scale of 1, all plants prostrate, to 9, all plants erect.

ψ Saturates = palmitate + stearate.

ϖ Check cultivars and lines used to compute % yield.

Table B3. (Cont.)

Line or family†	Seed yield	Seed yield	Maturity	Height	Lodging	Palmitate	Stearate	Oleate	Linoleate	Linolenate	Saturatesψ
	kg ha^{-1}	% check	days‡	cm	score§	g kg^{-1}					
1 7	2700	73	20	72	8	35	29	356	555	24	64
2 7	2209	59	20	62	8	30	30	443	477	19	60
3 7	2700	73	22	72	8	30	30	368	549	22	60
4 7	2414	65	20	67	8	37	33	264	633	33	70
Family 7 mean	2506	67	21	68	8	33	31	358	554	25	64
1 8	1677	45	39	82	7	40	35	259	639	27	75
2 8	2782	75	40	92	7	32	46	385	510	27	78
3 8	2455	66	39	82	7	33	46	334	558	29	79
4 8	1186	32	38	67	6	35	41	382	518	23	76
Family 8 mean	2025	54	39	81	7	35	42	340	556	27	77
1 9	1636	44	41	108	6	39	33	274	625	29	72
2 9	1800	48	40	103	6	40	36	262	628	33	76
3 9	2945	79	39	103	7	41	32	258	641	29	73
4 9	4255	114	41	113	7	37	32	270	631	30	69
Family 9 mean	2659	71	40	106	7	39	33	266	631	30	73
1 10	3395	91	40	103	7	38	31	267	635	28	69
2 10	3477	93	36	108	7	40	30	311	595	24	70
3 10	3191	86	39	92	4	37	28	284	624	27	65
4 10	1718	46	38	108	4	38	32	242	652	35	70
Family 10 mean	2945	79	38	103	6	38	30	276	627	29	69

Table B3. (Cont.)

Line or family†	Seed yield	Seed yield	Maturity	Height	Lodging	Palmitate	Stearate	Oleate	Linoleate	Linolenate	Saturatesψ
	kg ha^{-1}	% check	days‡	cm	score§	g kg^{-1}					
1 11	2536	68	24	87	7	38	31	244	657	30	69
2 11	3314	89	32	82	7	34	32	382	528	23	66
3 11	4009	108	39	103	8	36	32	297	605	30	68
4 11	3600	97	40	97	7	38	40	290	602	30	78
Family 11 mean	3365	90	34	92	7	37	34	303	598	28	70
1 12	2536	68	44	108	7	37	31	242	655	35	68
2 12	2823	76	46	108	7	35	32	240	662	31	67
3 12	2700	73	44	108	7	37	34	236	655	38	71
4 12	2536	68	44	103	7	40	29	296	608	27	69
Family 12 mean	2649	71	45	106	7	37	32	254	645	33	69
1 13	3191	86	32	92	7	53	31	271	586	60	84
2 13	3150	85	32	108	8	104	47	242	538	69	151
3 13	3314	89	24	82	8	37	29	346	561	27	66
4 13	3027	81	33	97	6	36	27	292	620	24	63
Family 13 mean	3170	85	30	95	7	58	34	288	576	45	91
1 14	3845	103	36	108	6	39	33	227	670	30	72
2 14	2414	65	33	82	7	42	34	245	654	26	76
3 14	3027	81	36	97	8	37	30	285	618	29	67
4 14	2332	63	35	87	7	41	33	244	654	28	74
Family 14 mean	2905	78	35	94	7	40	33	250	649	28	72

Table B3. (Cont.)

Line or family†	Seed yield	Seed yield	Maturity	Height	Lodging	Palmitate	Stearate	Oleate	Linoleate	Linolenate	Saturatesψ
	kg ha^{-1}	% check	days‡	cm	score§	g kg^{-1}					
1 15	2577	69	18	82	7	37	26	331	582	24	63
2 15	3273	88	21	92	6	39	37	282	611	31	76
3 15	2332	63	33	113	6	38	28	281	629	24	66
4 15	3191	86	24	108	6	34	29	311	597	28	63
Family 15 mean	2843	76	24	99	6	37	30	301	605	27	67
1 16	2455	66	42	97	7	37	32	291	609	31	69
2 16	2864	77	42	82	8	37	33	291	604	34	70
3 16	3395	91	40	97	8	39	32	262	638	28	71
4 16	2782	75	42	92	7	38	33	276	619	33	71
Family 16 mean	2874	77	42	92	8	38	33	280	618	32	70
1 17	3477	93	33	87	8	38	32	279	621	29	70
2 17	2291	62	34	87	7	37	29	278	628	28	66
3 17	3232	87	35	97	7	35	32	307	598	27	67
4 17	2986	80	25	87	7	34	25	388	530	22	59
Family 17 mean	2997	80	32	90	7	36	30	313	594	27	66
1 18	3682	99	38	97	7	35	29	288	620	27	64
2 18	3109	84	38	92	8	37	32	280	618	32	69
3 18	2864	77	41	103	7	37	36	265	632	29	73
4 18	3559	96	37	92	7	37	35	277	625	25	72
Family 18 mean	3303	89	39	96	7	37	33	278	624	28	70

Table B3. (Cont.)

Line or family†	Seed yield	Seed yield	Maturity	Height	Lodging	Palmitate	Stearate	Oleate	Linoleate	Linolenate	Saturatesψ
	kg ha^{-1}	% check	days‡	cm	score§	g kg^{-1}					
1 19	3150	85	43	97	7	36	33	289	612	28	69
2 19	3314	89	38	92	7	37	30	304	601	28	67
3 19	3314	89	38	97	8	37	35	310	592	25	72
4 19	3436	92	41	92	8	37	37	284	612	29	74
Family 19 mean	3303	89	40	95	8	37	34	297	604	28	71
1 20	4705	126	27	97	7	32	28	343	572	24	60
2 20	3027	81	26	82	7	38	35	313	590	23	73
3 20	3150	85	23	77	7	34	34	311	592	28	68
4 20	2864	77	22	72	7	34	28	403	510	24	62
Family 20 mean	3436	92	25	82	7	35	31	343	566	25	66
1 21	2945	79	41	103	7	36	33	298	599	33	69
2 21	3150	85	38	103	7	41	34	290	597	38	75
3 21	3477	93	39	92	6	36	35	311	591	27	71
4 21	3436	92	39	97	7	38	34	301	599	28	72
Family 21 mean	3252	87	39	99	7	38	34	300	597	32	72
1 22	2823	76	41	87	8	37	32	266	638	27	69
2 22	3232	87	41	82	8	37	34	286	615	28	71
3 22	2373	64	39	82	8	45	39	285	606	25	84
4 22	1964	53	16	56	8	38	29	281	626	26	67
Family 22 mean	2598	70	34	77	8	39	34	280	621	27	73

Table B3. (Cont.)

Line or family†	Seed yield	Seed yield	Maturity	Height	Lodging	Palmitate	Stearate	Oleate	Linoleate	Linolenate	Saturatesψ
	kg ha^{-1}	% check	days‡	cm	score§	g kg^{-1}					
1 23	2945	79	40	97	8	38	42	269	622	29	80
2 23	3314	89	36	92	8	40	38	268	627	27	78
3 23	2577	69	41	97	7	40	40	250	640	30	80
4 23	3273	88	36	92	8	37	38	235	661	29	75
Family 23 mean	3027	81	38	95	8	39	40	256	638	29	78
1 24	4173	112	24	77	8	38	34	302	599	26	72
2 24	3436	92	24	77	8	36	34	298	607	26	70
3 24	3232	87	21	72	8	37	33	331	577	22	70
4 24	3436	92	25	87	7	34	33	276	632	25	67
Family 24 mean	3569	96	24	78	8	36	34	302	604	25	70
Pioneer 9172ϖ	3477		18	87	7	98	34	212	577	79	132
Pioneer 9281ϖ	3436		26	82	8	105	36	229	561	68	141
Pioneer 9342ϖ	4500		37	92	8	110	38	218	547	85	148
Pioneer 9381ϖ	4295		41	103	7	102	40	224	555	78	142
Pioneer 9243ϖ	3805		26	92	7	57	29	240	602	72	86
YB27Gϖ	2209		29	87	7	35	29	221	620	94	64
YA7343Z006	3314		30	92	7	38	31	274	596	61	69
XB26C	.		.	.	.	.	.	.	.	.	.
XB36Iϖ	4132		33	103	7	99	46	283	549	24	145

Table B3. (Cont.)

Line or family†	Seed yield	Seed yield	Maturity	Height	Lodging	Palmitate	Stearate	Oleate	Linoleate	Linolenate	Saturates¥
	kg ha^{-1}	% check	days‡	cm	score§	g kg^{-1}					
Pioneer 9253ϖ	3109		24	92	6	113	45	276	540	25	158
Pioneer 9282ϖ	3845		26	97	7	107	36	288	541	26	143
Pioneer 9322ϖ	4418		35	92	7	107	41	224	602	26	148

Table B4. Performance of lines and families in the plant-row-yield test in 1995 for population AX11104.

Line or family†	Seed yield	Seed yield	Maturity	Height	Lodging	Palmitate	Stearate	Oleate	Linoleate	Linolenate	Saturatesψ
	kg ha^{-1}	% check	days‡	cm	score§	g kg^{-1}					
1 4	2659	68	24	87	6	37	27	339	573	23	64
2 4	3191	82	24	92	7	37	30	302	605	25	67
3 4	2741	70	26	82	7	36	29	312	597	26	65
4 4	3968	101	32	97	6	39	35	294	605	27	74
Family 4 mean	3140	80	27	90	7	37	30	312	595	25	68
1 5	3723	95	24	87	7	37	28	288	621	26	65
2 5	3436	88	24	87	7	38	28	298	609	27	66
3 5	4050	103	24	92	8	38	29	278	627	27	67
4 5	3355	86	24	87	8	36	28	278	630	28	64
Family 5 mean	3641	93	24	88	8	37	28	286	622	27	66
1 6	2577	66	18	72	7	35	27	252	658	26	62
2 6	1800	46	25	77	7	39	27	237	666	30	66
3 6	3559	91	25	72	7	35	29	248	661	26	64
4 6	2659	68	22	77	7	34	28	270	640	26	62
Family 6 mean	2649	68	23	74	7	36	28	252	656	27	64

† Line = first number represents the line within the family and the second number represents the family; family mean = the mean of the four lines within the family.

‡ Days = days after 31 August when 95% of the pods within a plot had reached their mature color.

§ Score = on a scale of 1, all plants prostrate, to 9, all plants erect.

ψ Saturates = palmitate + stearate.

ϖ Check cultivars and lines used to compute % yield.

Table B4. (Cont.)

Line or family†	Seed yield	Seed yield	Maturity	Height	Lodging	Palmitate	Stearate	Oleate	Linoleate	Linolenate	Saturatesψ
	kg ha^{-1}	% check	days‡	cm	score§	g kg^{-1}					
1 7	3232	83	25	77	7	35	32	326	580	26	67
2 7	3232	83	27	87	7	37	34	271	626	32	71
3 7	3559	91	26	82	7	38	31	255	640	36	69
4 7	3886	99	37	92	7	34	34	274	634	23	68
Family 7 mean	3477	89	29	85	7	36	33	282	620	29	69
1 8	3395	87	39	103	7	39	32	232	669	27	71
2 8	3436	88	37	97	7	43	32	238	656	31	75
3 8	3600	92	42	118	6	35	33	235	667	29	68
4 8	3518	90	40	92	8	36	32	255	650	27	68
Family 8 mean	3488	89	40	103	7	38	32	240	661	29	71
1 9	3559	91	25	82	7	36	33	259	631	41	69
2 9	3436	88	25	87	7	37	35	291	601	36	72
3 9	4009	102	26	87	8	37	33	301	601	27	70
4 9	3436	88	29	82	7	38	35	282	617	27	73
Family 9 mean	3610	92	26	85	7	37	34	283	613	33	71
1 10	2700	69	22	72	7	36	28	271	639	26	64
2 10	4255	109	39	97	7	36	33	241	662	28	69
3 10	2905	74	41	103	6	40	39	237	651	33	79
4 10	4132	106	38	92	8	39	31	219	681	29	70
Family 10 mean	3498	89	35	91	7	38	33	242	658	29	71

Table B4. (Cont.)

Line or family†	Seed yield	Seed yield	Maturity	Height	Lodging	Palmitate	Stearate	Oleate	Linoleate	Linolenate	Saturatesψ
	kg ha^{-1}	% check	days‡	cm	score§	g kg^{-1}					
1 11	2905	74	20	77	7	37	29	285	607	42	66
2 11	2577	66	20	77	7	37	27	319	576	40	64
3 11	2659	68	20	77	7	37	26	298	601	38	63
4 11	2905	74	20	87	7	36	26	356	553	29	62
Family 11 mean	2761	71	20	79	7	37	27	315	584	37	64
1 12	3232	83	34	108	6	86	34	265	553	62	120
2 12	2905	74	17	82	6	36	27	298	606	32	63
3 12	3027	77	19	92	7	34	26	385	522	33	60
4 12	3477	89	20	87	7	33	26	374	533	34	59
Family 12 mean	3160	81	23	92	7	47	28	331	554	40	76
1 13	3764	96	23	97	7	37	32	285	622	25	69
2 13	3027	77	23	92	7	37	29	266	645	22	66
3 13	3600	92	23	97	7	36	29	276	633	26	65
4 13	3191	82	26	92	6	37	30	270	639	24	67
Family 13 mean	3395	87	24	95	7	37	30	274	635	24	67
1 14	3559	91	38	113	7	40	33	219	678	30	73
2 14	2905	74	39	108	6	38	33	229	671	28	71
3 14	3027	77	42	113	7	39	32	219	679	29	71
4 14	3273	84	42	113	7	38	34	241	658	29	72
Family 14 mean	3191	82	40	112	7	39	33	227	672	29	72

Table B4. (Cont.)

Line or family†	Seed yield	Seed yield	Maturity	Height	Lodging	Palmitate	Stearate	Oleate	Linoleate	Linolenate	Saturatesψ
	kg ha^{-1}	% check	days‡	cm	score§	g kg^{-1}					
1 15	3355	86	26	82	8	37	33	312	591	27	70
2 15	3436	88	20	87	8	36	31	358	547	27	67
3 15	3273	84	23	87	8	35	31	357	541	35	66
4 15	3559	91	26	82	8	35	32	362	532	38	67
Family 15 mean	3406	87	24	85	8	36	32	347	553	32	68
1 16	3232	83	23	82	8	37	29	235	656	42	66
2 16	2864	73	24	77	7	39	28	262	633	38	67
3 16	3273	84	23	87	8	37	29	279	613	41	66
4 16	2659	68	24	82	7	37	27	257	640	40	64
Family 16 mean	3007	77	24	82	8	38	28	258	636	40	66
1 17	3886	99	34	97	7	37	32	239	664	28	69
2 17	2332	60	18	67	7	37	26	224	685	27	63
3 17	3477	89	31	87	7	39	29	227	675	30	68
4 17	2700	69	22	82	8	38	27	243	664	28	65
Family 17 mean	3099	79	26	83	7	38	29	233	672	28	66
1 18	2659	68	20	82	7	35	28	307	609	22	63
2 18	2495	64	18	82	7	37	28	275	634	25	65
3 18	3232	83	29	92	5	38	31	245	659	27	69
4 18	2905	74	17	82	7	35	31	275	634	24	66
Family 18 mean	2823	72	21	85	7	36	30	276	634	25	66

Table B4. (Cont.)

Line or family†	Seed yield	Seed yield	Maturity	Height	Lodging	Palmitate	Stearate	Oleate	Linoleate	Linolenate	Saturatesψ
	kg ha^{-1}	% check	days‡	cm	score§	g kg^{-1}					
1 19	2618	67	33	108	5	40	34	234	665	28	74
2 19	3273	84	34	97	6	38	31	231	670	29	69
3 19	3027	77	23	97	7	37	27	280	628	27	64
4 19	3355	86	34	113	6	40	31	220	681	28	71
Family 19 mean	3068	78	31	104	6	39	31	241	661	28	70
1 20	3068	78	31	103	5	38	28	293	616	25	66
2 20	2700	69	31	103	4	41	32	249	648	29	73
3 20	3150	80	34	97	6	38	31	287	617	26	69
4 20	2618	67	33	97	5	38	30	303	600	28	68
Family 20 mean	2884	74	32	100	5	39	30	283	620	27	69
1 21	2373	61	36	103	2	38	29	243	660	28	67
2 21	3477	89	41	108	5	36	34	235	666	28	70
3 21	2782	71	38	92	7	36	32	236	667	29	68
4 21	3723	95	43	108	7	35	33	238	667	27	68
Family 21 mean	3089	79	40	103	5	36	32	238	665	28	68
1 22	3600	92	37	103	7	39	30	235	666	30	69
2 22	3436	88	36	108	6	39	34	279	622	25	73
3 22	3723	95	35	108	7	36	36	286	613	29	72
4 22	3518	90	36	103	6	38	33	249	651	28	71
Family 22 mean	3569	91	36	105	7	38	33	262	638	28	71

Table B4. (Cont.)

Line or family†	Seed yield	Seed yield	Maturity	Height	Lodging	Palmitate	Stearate	Oleate	Linoleate	Linolenate	Saturatesψ
	kg ha^{-1}	% check	days‡	cm	score§	g kg^{-1}					
1 23	3150	80	19	92	7	37	27	301	609	26	64
2 23	3150	80	19	82	7	35	29	302	608	26	64
3 23	3150	80	19	82	7	34	26	264	649	28	60
4 23	3027	77	19	82	7	37	29	279	629	26	66
Family 23 mean	3119	80	19	85	7	36	28	287	624	27	64
1 24	3314	85	39	108	7	37	36	277	605	45	73
2 24	3355	86	38	97	6	37	32	303	602	25	69
3 24	3027	77	36	97	5	36	32	303	590	38	68
4 24	3682	94	41	113	6	36	37	268	616	44	73
Family 24 mean	3344	85	39	104	6	37	34	288	603	38	71
Pioneer 9172ϖ	3968		17	87	8	102	33	199	586	79	135
Pioneer 9281ϖ	4091		27	87	8	102	36	216	565	79	138
Pioneer 9342ϖ	3968		34	97	7	111	41	261	512	75	152
Pioneer 9381ϖ	4173		37	103	8	103	47	254	530	66	150
Pioneer 9243ϖ	3273		27	97	6	37	28	266	598	70	65
YB27Gϖ	3027		26	82	7	35	29	244	609	83	64
AX8154A370	4255		29	87	7	36	29	235	620	80	65
XB26C	.		.	.	.	.	.	.	.	.	.
XB36Iϖ	4541		35	108	8	94	44	263	577	22	138

Table B4. (Cont.)

Line or family†	Seed yield	Seed yield	Maturity	Height	Lodging	Palmitate	Stearate	Oleate	Linoleate	Linolenate	Saturatesψ
	kg ha^{-1}	% check	days‡	cm	score§	g kg^{-1}					
Pioneer 9253ϖ	4050		23	97	7	109	43	282	541	24	152
Pioneer 9282ϖ	4050		26	92	8	115	32	243	582	27	147
Pioneer 9322ϖ	4009		30	92	7	108	39	233	594	26	147

APPENDIX C: ANALYSIS OF VARIANCE OF TRAITS AT INDIVIDUAL ENVIRONMENTS.

Table C1. Analysis of variance for population AX11056 at Ames, IA in 1996.

		Mean squares											
Sources of variation	df	Seed yield	Maturity	Height	Lodging	Palmitate	Stearate	Oleate	Linoleate	Linolenate	Saturates	Protein	Oil
Replications (R)	1	386304**	1.2	76	0.04	9.1	5.7	231	532	8.1	29	20	24
F2 Families (F)	20	432136**	111**	243**	8.0**	23	47**	9712**	10111**	36*	61**	529**	243**
Lines within Families (L/F)	63	91929**	7.0**	33	0.8**	15**	5.0*	1219**	1075**	17**	24**	57**	72**
Error	83	38318	0.9	25	0.4	7.0	3.0	282	241	9.1	13	26	33
CV (%)		5.3	2.9	5.3	9.3	7.3	6.0	6.6	2.4	8.3	5.5	1.5	3.8

*, ** Significant at the 0.05 and 0.01 probability level, respectively.

Table C2. Analysis of variance for population AX11056 at Atlantic, IA in 1996.

		Mean squares									
Sources of variation	df	Seed yield	Maturity	Height	Lodging	Palmitate	Stearate	Oleate	Linoleate	Linolenate	Saturates
Replications (R)	1	14672	30**	662**	0.5	18	1.7	2859**	1807*	64**	9.0
F2 Families (F)	20	361598**	127**	391**	4.4**	63**	30**	9049**	8898**	26*	54
Lines within Families (L/F)	63	94351	5.9**	40**	0.6	24**	7.4*	858**	821**	12*	49**
Error	83	85771	1.9	15	0.6	9.5	4.7	296	308	7.3	23
CV (%)		8.9	5.4	4.5	10.4	8.3	7.1	6.7	2.7	8.3	7.0

*, ** Significant at the 0.05 and 0.01 probability level, respectively.

Table C3. Analysis of variance for population AX11056 at Bethany, MO in 1996.

		Mean squares						
Sources of variation	df	Seed yield	Palmitate	Stearate	Oleate	Linoleate	Linolenate	Saturates
Replications (R)	1	3663	48	17	15	572	71	122
F2 Families (F)	20	1293561**	28	51**	5730**	5643**	86**	66
Lines within Families (L/F)	63	173916*	26	9.3	686**	650**	37	47
Error	83	106584	17	10	369	330	37	34
CV (%)		15.1	11.3	10.5	8.9	2.7	15	8.7

*, ** Significant at the 0.05 and 0.01 probability level, respectively.

Table C4. Analysis of variance for population AX11056 at Washington, IA in 1996.

		Mean squares											
Sources of variation	df	Seed yield	Maturity	Height	Lodging	Palmitate	Stearate	Oleate	Linoleate	Linolenate	Saturates	Protein	Oil
Replications (R)	1	7768380**	120**	407**	0.9	129**	7.3	312	265	613**	75	83	215**
F2 Families (F)	20	657495**	120**	165**	6.7**	29	87**	4810**	5623**	24	110*	651**	319**
Lines within Families (L/F)	63	85003	7.0**	23	0.8**	25**	12**	617**	738**	15**	58**	82**	97**
Error	83	67584	3.2	19	0.4	8.8	5.9	125	160	6.8	22	36	24
CV (%)		9.4	4.7	5.6	9.2	7.9	7.4	4.9	1.9	8.0	6.7	1.8	3.0

*, ** Significant at the 0.05 and 0.01 probability level, respectively.

Table C5. Analysis of variance for population AX11063 at Ames, IA in 1996.

		Mean squares											
Sources of variation	df	Seed yield	Maturity	Height	Lodging	Palmitate	Stearate	Oleate	Linoleate	Linolenate	Saturates	Protein	Oil
Replications (R)	1	186	7.7*	2.7	0.5	2.4	0.1	122	192	0.1	3.1	138**	72**
F2 Families (F)	20	1171431**	162**	771**	8.0**	111**	32**	7587**	8750**	62**	196**	771**	345**
Lines within Families (L/F)	63	165658**	16**	73**	1.1**	24**	5.8*	804**	712**	22**	36**	48**	41**
Error	83	56411	1.2	24	0.3	3.7	3.7	220	229	4.7	7.9	19	10
CV (%)		6.1	3.3	5.1	8.7	5.0	5.9	5.8	2.4	6.3	3.9	1.3	1.9

*, ** Significant at the 0.05 and 0.01 probability level, respectively.

Table C6. Analysis of variance for population AX11063 at Atlantic, IA in 1996.

		Mean squares									
Sources of variation	*df*	Seed yield	Maturity	Height	Lodging	Palmitate	Stearate	Oleate	Linoleate	Linolenate	Saturates
Replications (R)	1	398873**	0.1	2817**	44**	61*	160**	178	1641**	24	418**
F2 Families (F)	20	1328455**	132**	849**	2.3**	162**	37**	4527**	5328**	24**	259**
Lines within Families (L/F)	63	144407**	14**	53**	0.5*	22	5.7*	455**	500**	10	39
Error	83	55347	0.9	23	0.4	15	3.5	166	195	7.3	27
CV (%)		7.0	3.7	6.0	7.9	10.0	5.7	5.1	2.2	9.1	7.3

*, ** Significant at the 0.05 and 0.01 probability level, respectively.

Table C7. Analysis of variance for population AX11063 at Bethany, MO in 1996.

		Mean squares						
Sources of variation	df	Seed yield	Palmitate	Stearate	Oleate	Linoleate	Linolenate	Saturates
Replications (R)	1	531529*	7.3	5.4	4.0	41	14	0.1
F2 Families (F)	20	1831049**	78**	25**	2875**	2877**	113**	109**
Lines within Families (L/F)	63	176640*	17	8.1*	316**	296**	33*	27*
Error	83	111584	13	5.5	145	141	20	17
CV (%)		14.4	9.3	6.9	5.4	1.8	11.9	5.7

*, ** Significant at the 0.05 and 0.01 probability level, respectively.

Table C8. Analysis of variance for population AX11063 at Washington, IA in 1996.

		Mean squares											
Sources of variation	df	Seed yield	Maturity	Height	Lodging	Palmitate	Stearate	Oleate	Linoleate	Linolenate	Saturates	Protein	Oil
Replications (R)	1	6239164**	245**	141*	3.7*	150**	688**	2958**	8500**	5.7	1482**	2648**	594**
F2 Families (F)	20	1846778**	140**	331**	6.7**	107**	49**	3821**	4746**	74**	217**	1438**	275**
Lines within Families (L/F)	63	127692	13**	37**	0.8	34**	6.0	347**	356**	26**	49**	96**	43**
Error	83	94107	4.0	21	0.7	5.0	6.6	125	168	5.1	15	30	10
CV (%)		10.3	5.2	5.9	12.7	5.5	7.2	4.9	2.0	7.1	5.1	1.6	1.7

*, ** Significant at the 0.05 and 0.01 probability level, respectively.

Table C9. Analysis of variance for population AX11080 at Ames, IA in 1996.

		Mean squares											
Sources of variation	df	Seed yield	Maturity	Height	Lodging	Palmitate	Stearate	Oleate	Linoleate	Linolenate	Saturates	Protein	Oil
Replications (R)	1	283335*	1.6	208**	6.9**	18	40*	83	61	30	113*	1430**	12
F2 Families (F)	20	869479**	214**	726**	6.8**	36**	104**	9334**	8992**	129**	204**	599**	361**
Lines within Families (L/F)	63	221885**	21**	101**	1.0**	10	10	1045**	1015**	17	23	89**	49**
Error	83	44766	1.6	29	0.3	8.0	7.0	390	333	22	20	22	19
CV (%)		5.8	4.1	6.1	7.3	8.0	9.1	7.9	2.8	13.7	6.8	1.3	2.7

*, ** Significant at the 0.05 and 0.01 probability level, respectively.

Table C10. Analysis of variance for population AX11080 at Atlantic, IA in 1996.

		Mean squares									
Sources of variation	df	Seed yield	Maturity	Height	Lodging	Palmitate	Stearate	Oleate	Linoleate	Linolenate	Saturates
Replications (R)	1	1042823**	12*	88	0.1	19	0.1	856	840	27	22
F2 Families (F)	20	606198**	260**	889**	1.7**	21	97**	4024**	4418**	44**	153**
Lines within Families (L/F)	63	189213**	19**	101**	0.5**	15*	14**	486**	480**	15**	43**
Error	83	72646	2.1	24	0.3	10	4.1	275	264	7.4	20
CV (%)		8.6	5.7	7.1	6.3	8.4	6.1	6.5	2.5	8.7	6.4

*, ** Significant at the 0.05 and 0.01 probability level, respectively.

Table C11. Analysis of variance for population AX11080 at Bethany, MO in 1996.

		Mean squares						
Sources of variation	df	Seed yield	Palmitate	Stearate	Oleate	Linoleate	Linolenate	Saturates
Replications (R)	1	67785	15	13	64	185	8.5	56
F2 Families (F)	20	1788712**	19	99**	3050**	3356**	75**	141**
Lines within Families (L/F)	63	246221**	13*	12	514**	538**	33*	34
Error	83	93313	8.7	8.9	217	264	19	28
CV (%)		14.0	8.2	9.5	6.9	2.4	11.1	7.9

*, ** Significant at the 0.05 and 0.01 probability level, respectively.

Table C12. Analysis of variance for population AX11080 at Washington, IA in 1996.

		Mean squares											
Sources of variation	df	Seed yield	Maturity	Height	Lodging	Palmitate	Stearate	Oleate	Linoleate	Linolenate	Saturates	Protein	Oil
Replications (R)	1	1753752**	2.3	7.9	1.3**	123**	484**	868*	5577**	166**	1096**	0.5	166*
F2 Families (F)	20	1177552**	255**	621**	4.2**	28**	151**	3819**	4590**	88**	255**	883**	833**
Lines within Families (L/F)	63	301068**	19**	70**	0.4**	12	12	573**	618**	19**	34	96**	64**
Error	83	95654	1.9	21	0.2	12	10	133	239	10	39	29	30
CV (%)		10.8	3.6	6.2	5.6	9.4	9.8	5.3	2.3	9.3	9.1	1.6	3.3

*, ** Significant at the 0.05 and 0.01 probability level, respectively.

Table C13. Analysis of variance for population AX11104 at Ames, IA in 1996.

		Mean squares											
Sources of variation	df	Seed yield	Maturity	Height	Lodging	Palmitate	Stearate	Oleate	Linoleate	Linolenate	Saturates	Protein	Oil
Replications (R)	1	7831	5.7*	1.5	1.0*	5.4	1.0	1221*	1020*	4.7	1.7	87*	40
F2 Families (F)	20	233216	218**	524**	9.0**	31	14**	5351**	6923**	307**	31	436**	339**
Lines within Families (L/F)	63	205744**	32**	81**	1.5**	53**	2.8	697**	501**	39**	62**	65**	56**
Error	83	33001	1.0	24	0.2	6.7	2.0	209	216	12	12	15	11
CV (%)		4.9	3.6	5.2	7.5	6.8	4.5	6.0	2.3	9.1	5.0	1.1	2.0

*, ** Significant at the 0.05 and 0.01 probability level, respectively.

Table C14. Analysis of variance for population AX11104 at Atlantic, IA in 1996.

		Mean squares									
Sources of variation	df	Seed yield	Maturity	Height	Lodging	Palmitate	Stearate	Oleate	Linoleate	Linolenate	Saturates
Replications (R)	1	193393	14	1.3	0.1	20	0.9	0.4	12	0.6	13
F2 Families (F)	20	227563	224**	554**	0.8*	72	13**	3562**	4813**	284**	82
Lines within Families (L/F)	63	262258**	20**	103**	0.4**	65**	4.0	475**	419**	33**	80**
Error	83	81351	4.1	15	0.2	10	3.0	119	145	9.4	17
CV (%)		9.0	8.5	4.7	5.5	8.3	5.2	4.7	1.8	9.1	5.7

*, ** Significant at the 0.05 and 0.01 probability level, respectively.

Table C15. Analysis of variance for population AX11104 at Bethany, MO in 1996.

		Mean squares						
Sources of variation	df	Seed yield	Palmitate	Stearate	Oleate	Linoleate	Linolenate	Saturates
Replications (R)	1	681182*	0.3	0.1	34	32	0.1	0.5
F2 Families (F)	20	672092**	61	17*	1992**	2559**	448**	75
Lines within Families (L/F)	63	205945**	63**	7.8	269**	377*	64**	88**
Error	83	101464	18	6.9	156	218	18	34
CV (%)		16.6	11.2	8.1	5.8	2.2	10.2	8.3

*, ** Significant at the 0.05 and 0.01 probability level, respectively.

Table C16. Analysis of variance for population AX11104 at Washington, IA in 1996.

		Mean squares											
Sources of variation	df	Seed yield	Maturity	Height	Lodging	Palmitate	Stearate	Oleate	Linoleate	Linolenate	Saturates	Protein	Oil
Replications (R)	1	294507*	23**	37	0.1	6.1	6.5	28	0.1	31	0.1	474**	692**
F2 Families (F)	20	999331**	218**	296**	5.9**	34	26**	2717**	3537**	301**	85**	495**	314**
Lines within Families (L/F)	63	264757**	28**	47**	1.2**	27**	8.7	349**	283**	51**	35**	52**	56**
Error	83	55306	2.0	16	0.3	2.9	8.2	89	92	11	13	18	6.1
CV (%)		8.3	3.9	5.2	7.2	4.4	8.4	4.4	1.4	9.1	5.0	1.2	1.3

*, ** Significant at the 0.05 and 0.01 probability level, respectively.

APPENDIX D: MEANS AND RANGES OF TRAITS ACROSS ENVIRONMENTS.

Table D1. Means and ranges of agronomic and seed traits of F_2 families for four populations combined across environments in 1996.

	AX11056		AX11063		AX11080		AX11104	
Trait	Mean	Range	Mean	Range	Mean	Range	Mean	Range
Seed yield (kg ha^{-1})	2979	2336 - 3284	3134	1663 - 3554	2962	2039 - 3367	2908	2554 - 3206
Maturity (days)	32	19 - 37	33	21 - 39	31	20 - 41	30	22 - 38
Height (cm)	86	69 - 93	85	67 - 104	77	56 - 91	84	72 - 94
Lodging (score)	6.7	5.0 - 8.3	6.8	5.4 - 8.0	7.5	6.1 - 8.4	7.0	5.9 - 8.0
Palmitate (g kg^{-1})	37	34 - 43	39	35 - 49	37	34 - 39	38	36 - 47
Stearate (g kg^{-1})	31	25 - 34	34	29 - 38	32	24 - 38	33	31 - 35
Oleate (g kg^{-1})	239	182 - 276	241	208 - 294	235	198 - 281	226	190 - 262
Linoleate (g kg^{-1})	658	621 - 714	653	604 - 686	662	620 - 703	665	626 - 702
Linolenate (g kg^{-1})	36	31 - 40	33	30 - 41	35	30 - 41	37	30 - 54
Saturates (g kg^{-1})	68	62 - 71	73	65 - 83	68	58 - 74	71	69 - 73
Protein (g kg^{-1})	343	327 - 366	339	316 - 356	344	325 - 362	354	338 - 370
Oil (g kg^{-1})	157	144 - 166	179	166 - 191	162	142 - 178	176	165 - 189

Table D2. Means and ranges of agronomic and seed traits for lines for four populations combined across environments in 1996.

	AX11056		AX11063		AX11080		AX11104	
Trait	Mean	Range	Mean	Range	Mean	Range	Mean	Range
Seed yield (kg ha^{-1})	2979	2061 - 3458	3134	1071 - 3753	2962	1650 - 3858	2908	1863 - 3509
Maturity (days)	32	19 - 39	33	18 - 39	31	19 - 42	30	20 - 41
Height (cm)	86	69 - 96	85	64 - 106	77	50 - 94	84	62 - 101
Lodging (score)	6.7	4.5 - 8.3	6.8	4.7 - 8.2	7.5	4.8 - 8.7	7.0	4.5 - 8.0
Palmitate (g kg^{-1})	37	29 - 51	39	35 - 56	37	32 - 43	38	35 - 77
Stearate (g kg^{-1})	31	22 - 35	34	29 - 38	32	24 - 40	33	30 - 37
Oleate (g kg^{-1})	239	161 - 299	241	206 - 315	235	189 - 295	226	183 - 278
Linoleate (g kg^{-1})	658	599 - 744	653	584 - 692	662	589 - 714	665	611 - 710
Linolenate (g kg^{-1})	36	29 - 46	33	27 - 52	35	27 - 48	37	29 - 73
Saturates (g kg^{-1})	68	51 - 78	73	64 - 93	68	56 - 78	71	66 - 109
Protein (g kg^{-1})	343	319 - 370	339	310 - 364	344	315 - 366	354	334 - 370
Oil (g kg^{-1})	157	132 - 168	179	163 - 199	162	139 - 184	176	156 - 196

APPENDIX E: VARIANCE COMPONENT ESTIMATES, HERITABILITY ESTIMATES, AND THEIR STANDARD ERRORS ACROSS ENVIRONMENTS.

Table E1. Variance component estimates, heritability estimates, and their standard errors for seed yield for four populations averaged across four environments in 1996.

	Population			
Estimate	AX11056	AX11063	AX11080	AX11104
Genetic, σ^2_G	56162.75 ± 7160.17	173346.52 ± 27908.95	164755.58 ± 26512.40	94249.02 ± 14968.33
Genetic X Environment, σ^2_{GE}	31469.97 ± 4079.96	31341.86 ± 4342.50	21665.75 ± 4191.75	25147.56 ± 3708.81
Error, σ^2_e	74564.00 ± 319.54	79362.00 ± 340.11	76607.00 ± 328.30	67781.00 ± 290.48
h^2, Plot basis	0.35 ± 0.04	0.61 ± 0.10	0.63 ± 0.10	0.50 ± 0.08
h^2, Entry-mean basis†	0.77 ± 0.10	0.91 ± 0.15	0.92 ± 0.15	0.86 ± 0.14

† two replications at Ames, Atlantic, Bethany, and Washington.

Table E2. Variance component estimates, heritability estimates, and their standard errors for maturity for four populations averaged across three environments in 1996.

	Population			
Estimate	AX11056	AX11063	AX11080	AX11104
Genetic, σ^2_G	15.27 ± 2.41	20.66 ± 3.26	34.90 ± 5.44	34.26 ± 5.37
Genetic X Environment, σ^2_{GE}	0.61 ± 0.13	1.10 ± 0.13	0.93 ± 0.11	1.23 ± 0.15
Error, σ^2_e	2.00 ± 0.01	2.00 ± 0.01	1.80 ± 0.01	2.40 ± 0.01
h^2, Plot basis	0.85 ± 0.13	0.87 ± 0.14	0.93 ± 0.14	0.90 ± 0.14
h^2, Entry-mean basis†	0.97 ± 0.15	0.97 ± 0.15	0.98 ± 0.15	0.98 ± 0.15

† two replications at Ames, Atlantic, and Washington.

Table E3. Variance component estimates, heritability estimates, and their standard errors for height for four populations averaged across three environments in 1996.

	Population			
Estimate	AX11056	AX11063	AX11080	AX11104
Genetic, σ^2_G	32.23 ± 5.24	82.35 ± 13.23	109.12 ± 17.36	68.92 ± 11.11
Genetic X Environment, σ^2_{GE}	2.63 ± 1.20	5.04 ± 1.45	3.13 ± 1.52	6.56 ± 1.14
Error, σ^2_e	19.00 ± 0.11	23.00 ± 0.13	24.00 ± 0.14	18.00 ± 0.10
h^2, Plot basis	0.60 ± 0.10	0.75 ± 0.12	0.80 ± 0.13	0.74 ± 0.12
h^2, Entry-mean basis†	0.89 ± 0.14	0.94 ± 0.15	0.96 ± 0.15	0.93 ± 0.15

† two replications at Ames, Atlantic, and Washington.

Table E4. Variance component estimates, heritability estimates, and their standard errors for lodging for four populations averaged across three environments in 1996.

	Population			
Estimate	AX11056	AX11063	AX11080	AX11104
Genetic, σ^2_G	0.71 ± 0.11	0.60 ± 0.09	13.44 ± 2.08	0.55 ± 0.08
Genetic X Environment, σ^2_{GE}	0.13 ± 0.03	0.17 ± 0.03	0.21 ± 0.01	0.38 ± 0.01
Error, σ^2_e	0.40 ± 0.01	0.50 ± 0.01	0.20 ± 0.01	0.20 ± 0.01
h^2, Plot basis	0.57 ± 0.09	0.47 ± 0.07	0.97 ± 0.15	0.48 ± 0.07
h^2, Entry-mean basis†	0.86 ± 0.14	0.81 ± 0.13	0.99 ± 0.15	0.77 ± 0.11

† two replications at Ames, Atlantic, and Washington.

Table E5. Variance component estimates, heritability estimates, and their standard errors for palmitate content for four populations averaged across four environments in 1996.

	Population			
Estimate	AX11056	AX11063	AX11080	AX11104
Genetic, σ^2_G	6.40 ± 0.91	16.09 ± 2.59	2.60 ± 0.01	19.35 ± 3.11
Genetic X Environment, σ^2_{GE}	1.14 ± 0.60	2.31 ± 0.51	0.44 ± 0.54	1.47 ± 0.52
Error, σ^2_e	11.00 ± 0.05	9.30 ± 0.04	9.80 ± 0.04	9.50 ± 0.04
h^2, Plot basis	0.35 ± 0.05	0.58 ± 0.09	0.20 ± 0.01	0.64 ± 0.10
h^2, Entry-mean basis†	0.79 ± 0.11	0.90 ± 0.15	0.66 ± 0.01	0.93 ± 0.15

† two replications at Ames, Atlantic, Bethany, and Washington.

Table E6. Variance component estimates, heritability estimates, and their standard errors for stearate content for four populations averaged across four environments in 1996.

	Population			
Estimate	AX11056	AX11063	AX11080	AX11104
Genetic, σ^2_G	6.12 ± 0.98	3.33 ± 0.48	13.09 ± 2.11	1.16 ± 0.01
Genetic X Environment, σ^2_{GE}	0.48 ± 0.33	0.99 ± 0.26	1.23 ± 0.42	0.64 ± 0.27
Error, σ^2_e	6.00 ± 0.03	4.80 ± 0.02	7.60 ± 0.03	5.00 ± 0.02
h^2, Plot basis	0.49 ± 0.08	0.37 ± 0.05	0.60 ± 0.10	0.17 ± 0.01
h^2, Entry-mean basis†	0.88 ± 0.14	0.80 ± 0.11	0.91 ± 0.15	0.60 ± 0.01

† two replications at Ames, Atlantic, Bethany, and Washington.

Table E7. Variance component estimates, heritability estimates, and their standard errors for oleate content for four populations averaged across four environments in 1996.

	Population			
Estimate	AX11056	AX11063	AX11080	AX11104
Genetic, σ^2_G	1004.40 ± 159.73	595.62 ± 95.30	654.97 ± 105.17	420.48 ± 67.68
Genetic X Environment, σ^2_{GE}	64.92 ± 14.66	71.43 ± 8.97	75.67 ± 13.90	88.25 ± 7.82
Error, σ^2_e	268.00 ± 1.15	164.00 ± 0.70	254.00 ± 1.09	143.00 ± 0.61
h^2, Plot basis	0.75 ± 0.12	0.72 ± 0.11	0.67 ± 0.11	0.65 ± 0.10
h^2, Entry-mean basis†	0.95 ± 0.15	0.94 ± 0.15	0.93 ± 0.15	0.91 ± 0.15

† two replications at Ames, Atlantic, Bethany, and Washington.

Table E8. Variance component estimates, heritability estimates, and their standard errors for linoleate content for four populations averaged across four environments in 1996.

	Population			
Estimate	AX11056	AX11063	AX11080	AX11104
Genetic, σ^2_G	1030.30 ± 163.64	678.03 ± 108.15	680.76 ± 109.34	513.23 ± 82.52
Genetic X Environment, σ^2_{GE}	63.16 ± 14.23	60.78 ± 10.01	76.70 ± 15.05	89.63 ± 9.19
Error, σ^2_e	260.00 ± 1.11	183.00 ± 0.78	275.00 ± 1.18	168.00 ± 0.72
h^2, Plot basis	0.76 ± 0.12	0.74 ± 0.12	0.66 ± 0.11	0.67 ± 0.11
h^2, Entry-mean basis†	0.96 ± 0.15	0.95 ± 0.15	0.93 ± 0.15	0.92 ± 0.15

† two replications at Ames, Atlantic, Bethany, and Washington.

Table E9. Variance component estimates, heritability estimates, and their standard errors for linolenate content for four populations averaged across four environments in 1996.

	Population			
Estimate	AX11056	AX11063	AX11080	AX11104
Genetic, σ^2_G	5.69 ± 0.71	9.59 ± 1.49	10.13 ± 1.56	51.26 ± 8.08
Genetic X Environment, σ^2_{GE}	0.42 ± 0.82	2.50 ± 0.51	0.46 ± 0.82	0.84 ± 0.66
Error, σ^2_e	15.00 ± 0.06	9.40 ± 0.04	15.00 ± 0.06	12.00 ± 0.05
h^2, Plot basis	0.28 ± 0.04	0.45 ± 0.07	0.40 ± 0.06	0.80 ± 0.13
h^2, Entry-mean basis†	0.76 ± 0.10	0.84 ± 0.13	0.84 ± 0.13	0.97 ± 0.15

† two replications at Ames, Atlantic, Bethany, and Washington.

Table E10. Variance component estimates, heritability estimates, and their standard errors for saturate content for four populations averaged across four environments in 1996.

	Population			
Estimate	AX11056	AX11063	AX11080	AX11104
Genetic, σ^2_G	11.38 ± 1.43	24.04 ± 3.84	20.12 ± 3.12	19.95 ± 3.15
Genetic X Environment, σ^2_{GE}	2.62 ± 1.26	5.41 ± 0.93	1.72 ± 1.48	3.95 ± 1.04
Error, σ^2_e	23.00 ± 0.10	17.00 ± 0.07	27.00 ± 0.12	19.00 ± 0.08
h^2, Plot basis	0.31 ± 0.04	0.52 ± 0.08	0.41 ± 0.06	0.47 ± 0.07
h^2, Entry-mean basis†	0.76 ± 0.10	0.87 ± 0.14	0.84 ± 0.13	0.86 ± 0.14

† two replications at Ames, Atlantic, Bethany, and Washington.

Table E11. Variance component estimates, heritability estimates, and their standard errors for protein content for four populations averaged across two environments in 1996.

	Population			
Estimate	AX11056	AX11063	AX11080	AX11104
Genetic, σ^2_G	78.51 ± 12.85	118.19 ± 19.31	97.37 ± 15.97	65.02 ± 10.61
Genetic X Environment, σ^2_{GE}	3.33 ± 2.39	329.96 ± 1.85	14.57 ± 1.93	5.27 ± 1.24
Error, σ^2_e	31.00 ± 0.27	24.00 ± 0.21	25.00 ± 0.22	16.00 ± 0.14
h^2, Plot basis	0.70 ± 0.11	0.69 ± 0.11	0.71 ± 0.12	0.75 ± 0.12
h^2, Entry-mean basis†	0.89 ± 0.15	0.85 ± 0.14	0.88 ± 0.14	0.91 ± 0.15

† two replications at Ames and Washington.

Table E12. Variance component estimates, heritability estimates, and their standard errors for oil content for four populations averaged across two environments in 1996.

	Population			
Estimate	AX11056	AX11063	AX11080	AX11104
Genetic, σ^2_G	49.91 ± 8.18	44.04 ± 7.19	69.95 ± 11.45	49.75 ± 8.13
Genetic X Environment, σ^2_{GE}	1.51 ± 2.24	4.44 ± 0.77	10.86 ± 1.93	6.18 ± 0.70
Error, σ^2_e	29.00 ± 0.25	10.00 ± 0.09	25.00 ± 0.22	9.00 ± 0.08
h^2, Plot basis	0.62 ± 0.10	0.75 ± 0.12	0.66 ± 0.11	0.77 ± 0.13
h^2, Entry-mean basis†	0.86 ± 0.14	0.90 ± 0.15	0.86 ± 0.14	0.90 ± 0.15

† two replications at Ames and Washington.

APPENDIX F: ERRORS FROM SELECTION BY THE FAMILY AND LINE METHODS.

Table F1. Selection for ≤ 38 g kg^{-1} palmitate content by the family and line methods in population AX11056 at four environments in 1996.

Environment	Family method							Line method						
	Lines selected	Error						Lines selected	Error					
		None†		Acceptance‡		Rejection§			None†		Acceptance‡		Rejection§	
	no.	no.	%	no.	%	no.	%	no.	no.	%	no.	%	no.	%
Ames														
Rep 1	77	68	88	9	12	2	3	79	68	86	11	14	2	3
Rep 2	63	56	89	7	11	14	20	72	63	88	9	13	7	10
Rep mean	75	66	88	9	12	4	6	77	66	86	11	14	4	6
Washington														
Rep 1	32	32	100	0	0	41	56	56	50	89	6	11	23	32
Rep 2	52	50	96	2	4	23	32	56	52	93	4	7	21	29
Rep mean	48	46	96	2	4	27	37	55	51	93	4	7	22	30
Bethany														
Rep 1	58	52	90	6	10	19	27	73	64	88	9	12	7	10
Rep 2	67	62	93	5	7	9	13	71	64	90	7	10	7	10
Rep mean	67	61	91	6	9	10	14	69	61	88	8	12	10	14
Atlantic														
Rep 1	69	63	91	6	9	11	15	70	64	91	6	9	10	14
Rep 2	67	61	91	6	9	12	16	70	64	91	6	9	9	12
Rep mean	68	62	91	6	9	11	15	69	63	91	6	9	10	14
Average														
Individual rep	61	56	92	5	8	16	23	68	61	89	7	11	11	15
Rep mean	65	59	91	6	9	13	18	68	60	90	7	10	12	16

† None = (no. of lines selected without error ÷ no. of lines selected) x 100.
‡ Acceptance = (no. of lines incorrectly accepted ÷ no. of lines selected) x 100.
§ Rejection = [no. of lines incorrectly rejected ÷ (no. of lines selected without error + no. of lines incorrectly rejected)] x 100.

Table F2. Selection for ≤ 38 g kg^{-1} palmitate content by the family and line methods in population AX11063 at four environments in 1996.

Environment	Family method							Line method						
	Lines selected	Error						Lines selected	Error					
		None†		Acceptance‡		Rejection§			None†		Acceptance‡		Rejection§	
	no.	no.	%	no.	%	no.	%	no.	no.	%	no.	%	no.	%
Ames														
Rep 1	55	30	55	25	45	7	19	63	33	52	30	48	4	11
Rep 2	49	28	57	21	43	9	24	60	31	52	29	48	6	16
Rep mean	52	27	52	25	48	10	27	60	30	50	30	50	7	19
Washington														
Rep 1	24	19	79	5	21	32	63	33	26	79	7	21	25	49
Rep 2	10	8	80	2	20	43	84	16	13	81	3	19	38	75
Rep mean	14	11	79	3	21	40	78	23	19	83	4	17	32	63
Bethany														
Rep 1	30	22	73	8	27	24	52	46	29	63	17	37	17	37
Rep 2	34	27	79	7	21	19	41	51	36	71	15	29	10	22
Rep mean	31	22	71	9	29	24	52	42	28	67	14	33	18	39
Atlantic														
Rep 1	53	26	49	27	51	13	33	60	31	52	29	48	8	21
Rep 2	32	20	63	12	38	19	49	43	25	58	18	42	14	36
Rep mean	42	22	52	20	48	17	44	51	26	51	25	49	13	33
Average														
Individual rep	36	23	63	13	37	21	48	47	28	60	19	40	15	35
Rep mean	35	21	59	14	41	23	53	44	26	59	18	41	18	40

† None = (no. of lines selected without error ÷ no. of lines selected) x 100.
‡ Acceptance = (no. of lines incorrectly accepted ÷ no. of lines selected) x 100.
§ Rejection = [no. of lines incorrectly rejected ÷ (no. of lines selected without error + no. of lines incorrectly rejected)] x 100.

Table F3. Selection for ≤ 38 g kg^{-1} palmitate content by the family and line methods in population AX11080 at four environments in 1996.

Environment	Family method							Line method						
	Lines selected	Error						Lines selected	Error					
		None†		Acceptance‡		Rejection§			None†		Acceptance‡		Rejection§	
	no.	no.	%	no.	%	no.	%	no.	no.	%	no.	%	no.	%
Ames														
Rep 1	67	61	91	6	9	9	13	72	65	90	7	10	5	7
Rep 2	62	54	87	8	13	16	23	67	58	87	9	13	12	17
Rep mean	68	59	87	9	13	10	14	68	59	87	9	13	10	14
Washington														
Rep 1	55	50	91	5	9	20	29	62	54	87	8	13	16	23
Rep 2	54	46	85	8	15	24	34	59	50	85	9	15	20	29
Rep mean	58	52	90	6	10	18	26	65	57	88	8	12	13	19
Bethany														
Rep 1	72	54	75	18	25	10	16	75	57	76	18	24	7	11
Rep 2	67	56	84	11	16	8	13	74	61	82	13	18	3	5
Rep mean	70	56	80	14	20	8	13	75	60	80	15	20	4	6
Atlantic														
Rep 1	57	53	93	4	7	18	25	61	56	92	5	8	15	21
Rep 2	52	48	92	4	8	23	32	57	52	91	5	9	19	27
Rep mean	51	48	94	3	6	23	32	53	50	94	3	6	21	30
Average														
Individual rep	61	53	87	8	13	16	23	66	57	86	9	14	12	18
Rep mean	62	54	87	8	13	15	22	65	57	87	9	13	12	18

† None = (no. of lines selected without error ÷ no. of lines selected) x 100.
‡ Acceptance = (no. of lines incorrectly accepted ÷ no. of lines selected) x 100.
§ Rejection = [no. of lines incorrectly rejected ÷ (no. of lines selected without error + no. of lines incorrectly rejected)] x 100.

Table F4. Selection for ≤ 38 g kg^{-1} palmitate content by the family and line methods in population AX11104 at four environments in 1996.

Environment	Family method							Line method						
	Lines selected	Error						Lines selected	Error					
		None†		Acceptance‡		Rejection§			None†		Acceptance‡		Rejection§	
	no.	no.	%	no.	%	no.	%	no.	no.	%	no.	%	no.	%
Ames														
Rep 1	37	32	86	5	14	30	48	59	46	78	13	22	16	26
Rep 2	49	38	78	11	22	24	39	67	52	78	15	22	10	16
Rep mean	45	38	84	7	16	24	39	58	47	81	11	19	15	24
Washington														
Rep 1	53	43	81	10	19	16	27	61	48	79	13	21	11	19
Rep 2	43	32	74	11	26	27	46	57	41	72	16	28	18	31
Rep mean	48	38	79	10	21	21	36	54	43	80	11	20	16	27
Bethany														
Rep 1	53	39	74	14	26	19	33	61	46	75	15	25	12	21
Rep 2	61	45	74	16	26	13	22	71	52	73	19	27	6	10
Rep mean	50	38	76	12	24	20	34	64	49	77	15	23	9	16
Atlantic														
Rep 1	34	29	85	5	15	35	55	51	44	86	7	14	20	31
Rep 2	45	38	84	7	16	26	41	54	46	85	8	15	18	28
Rep mean	43	36	84	7	16	28	44	49	42	86	7	14	22	34
Average														
Individual rep	47	37	79	10	21	24	39	60	47	78	13	22	14	23
Rep mean	47	38	81	9	19	23	38	56	45	80	11	20	16	26

† None = (no. of lines selected without error ÷ no. of lines selected) x 100.
‡ Acceptance = (no. of lines incorrectly accepted ÷ no. of lines selected) x 100.
§ Rejection = [no. of lines incorrectly rejected ÷ (no. of lines selected without error + no. of lines incorrectly rejected)] x 100.

Table F5. Selection for ≤ 70 g kg^{-1} saturates content by the family and line methods in population AX11056 at four environments in 1996.

Environment	Family method							Line method						
	Lines selected	Error						Lines selected	Error					
		None†		Acceptance‡		Rejection§			None†		Acceptance‡		Rejection§	
	no.	no.	%	no.	%	no.	%	no.	no.	%	no.	%	no.	%
Ames														
Rep 1	77	54	70	23	30	2	4	79	54	68	25	32	2	4
Rep 2	74	52	70	22	30	4	7	77	54	70	23	30	2	4
Rep mean	79	55	70	24	30	1	2	79	55	70	24	30	1	2
Washington														
Rep 1	27	26	96	1	4	50	66	36	34	94	2	6	42	55
Rep 2	34	32	94	2	6	44	58	44	41	93	3	7	35	46
Rep mean	28	26	93	2	7	50	66	40	38	95	2	5	38	50
Bethany														
Rep 1	51	42	82	9	18	21	33	59	46	78	13	22	17	27
Rep 2	60	47	78	13	22	17	27	65	51	78	14	22	13	20
Rep mean	64	51	80	13	20	12	19	66	53	80	13	20	10	16
Atlantic														
Rep 1	63	54	86	9	14	13	19	70	58	83	12	17	9	13
Rep 2	64	52	81	12	19	15	22	65	53	82	12	18	14	21
Rep mean	62	51	82	11	18	16	24	64	53	83	11	17	14	21
Average														
Individual rep	56	45	80	11	20	21	32	62	49	79	13	21	17	26
Rep mean	58	46	79	13	21	20	30	62	50	80	13	20	16	24

† None = (no. of lines selected without error ÷ no. of lines selected) x 100.
‡ Acceptance = (no. of lines incorrectly accepted ÷ no. of lines selected) x 100.
§ Rejection = [no. of lines incorrectly rejected ÷ (no. of lines selected without error + no. of lines incorrectly rejected)] x 100.

Table F6. Selection for ≤ 70 g kg^{-1} saturates content by the family and line methods in population AX11063 at four environments in 1996.

Environment	Family method							Line method						
	Lines selected	Error						Lines selected	Error					
		None†		Acceptance‡		Rejection§			None†		Acceptance‡		Rejection§	
	no.	no.	%	no.	%	no.	%	no.	no.	%	no.	%	no.	%
Ames														
Rep 1	39	15	38	24	62	3	17	51	16	31	35	69	2	11
Rep 2	44	16	36	28	64	2	11	50	17	34	33	66	1	6
Rep mean	43	15	35	28	65	3	17	48	16	33	32	67	2	11
Washington														
Rep 1	17	12	71	5	29	21	64	28	17	61	11	39	16	48
Rep 2	3	3	100	0	0	30	91	4	4	100	0	0	29	88
Rep mean	4	4	100	0	0	30	88	8	6	75	2	25	28	82
Bethany														
Rep 1	6	4	67	2	33	24	86	22	11	50	11	50	17	61
Rep 2	18	11	61	7	39	16	59	27	15	56	12	44	12	44
Rep mean	12	8	67	4	33	20	71	22	11	50	11	50	17	61
Atlantic														
Rep 1	47	17	36	30	64	2	11	53	18	34	35	66	1	5
Rep 2	13	9	69	4	31	10	53	30	13	43	17	57	6	32
Rep mean	30	14	47	16	53	5	26	42	17	40	25	60	2	11
Average														
Individual rep	23	11	47	13	53	14	55	33	14	42	19	58	11	43
Rep mean	22	10	46	12	54	15	59	30	13	42	18	58	12	49

† None = (no. of lines selected without error ÷ no. of lines selected) x 100.
‡ Acceptance = (no. of lines incorrectly accepted ÷ no. of lines selected) x 100.
§ Rejection = [no. of lines incorrectly rejected ÷ (no. of lines selected without error + no. of lines incorrectly rejected)] x 100.

Table F7. Selection for ≤ 70 g kg^{-1} saturates content by the family and line methods in population AX11080 at four environments in 1996.

Environment	Family method							Line method						
	Lines selected	Error						Lines selected	Error					
		None†		Acceptance‡		Rejection§			None†		Acceptance‡		Rejection§	
	no.	no.	%	no.	%	no.	%	no.	no.	%	no.	%	no.	%
Ames														
Rep 1	61	48	79	13	21	3	6	66	48	73	18	27	3	6
Rep 2	48	41	85	7	15	10	20	61	46	75	15	25	5	10
Rep mean	57	46	81	11	19	5	10	65	48	74	17	26	3	6
Washington														
Rep 1	29	26	90	3	10	26	50	37	32	86	5	14	20	38
Rep 2	41	28	68	13	32	24	46	53	30	57	23	43	22	42
Rep mean	42	32	76	10	24	20	38	46	34	74	12	26	18	35
Bethany														
Rep 1	53	42	79	11	21	12	22	57	44	77	13	23	10	19
Rep 2	49	41	84	8	16	13	24	60	46	77	14	23	8	15
Rep mean	51	42	82	9	18	12	22	55	43	78	12	22	11	20
Atlantic														
Rep 1	37	36	97	1	3	20	36	43	40	93	3	7	16	29
Rep 2	29	28	97	1	3	28	50	41	35	85	6	15	21	38
Rep mean	35	34	97	1	3	22	39	42	38	90	4	10	18	32
Average														
Individual rep	43	36	84	7	16	17	32	52	40	77	12	23	13	25
Rep mean	46	39	83	8	17	15	28	52	41	78	11	22	13	23

† None = (no. of lines selected without error ÷ no. of lines selected) x 100.
‡ Acceptance = (no. of lines incorrectly accepted ÷ no. of lines selected) x 100.
§ Rejection = [no. of lines incorrectly rejected ÷ (no. of lines selected without error + no. of lines incorrectly rejected)] x 100.

Table F8. Selection for ≤ 70 g kg^{-1} saturates content by the family and line methods in population AX11104 at four environments in 1996.

Environment	Family method							Line method						
	Lines selected	Error						Lines selected	Error					
		None†		Acceptance‡		Rejection§			None†		Acceptance‡		Rejection§	
	no.	no.	%	no.	%	no.	%	no.	no.	%	no.	%	no.	%
Ames														
Rep 1	41	20	49	21	51	10	33	57	24	42	33	58	6	20
Rep 2	44	21	48	23	52	9	30	59	29	49	30	51	1	3
Rep mean	38	20	53	18	47	10	33	54	25	46	29	54	5	17
Washington														
Rep 1	17	14	82	3	18	35	71	30	21	70	9	30	28	57
Rep 2	13	7	54	6	46	42	86	31	22	71	9	29	27	55
Rep mean	13	10	77	3	23	40	80	23	17	74	6	26	33	66
Bethany														
Rep 1	40	20	50	20	50	17	46	50	27	54	23	46	10	27
Rep 2	42	18	43	24	57	19	51	58	25	43	33	57	12	32
Rep mean	34	14	41	20	59	23	62	50	22	44	28	56	15	41
Atlantic														
Rep 1	17	12	71	5	29	30	71	33	23	70	10	30	19	45
Rep 2	22	17	77	5	23	24	59	36	24	67	12	33	17	41
Rep mean	18	12	67	6	33	30	71	30	19	63	11	37	23	55
Average														
Individual rep	30	16	55	13	45	23	59	44	24	55	20	45	15	38
Rep mean	26	14	54	12	46	26	65	39	21	53	19	47	19	48

† None = (no. of lines selected without error ÷ no. of lines selected) x 100.
‡ Acceptance = (no. of lines incorrectly accepted ÷ no. of lines selected) x 100.
§ Rejection = [no. of lines incorrectly rejected ÷ (no. of lines selected without error + no. of lines incorrectly rejected)] x 100.

Table F9. Selection for ≤ 35 g kg^{-1} linolenate content by the family and line methods in population AX11056 at four environments in 1996.

Environment	Family method							Line method						
	Lines selected	Error						Lines selected	Error					
		None†		Acceptance‡		Rejection§			None†		Acceptance‡		Rejection§	
	no.	no.	%	no.	%	no.	%	no.	no.	%	no.	%	no.	%
Ames														
Rep 1	27	19	70	8	30	27	59	39	26	67	13	33	20	43
Rep 2	15	12	80	3	20	34	74	33	22	67	11	33	24	52
Rep mean	18	12	67	6	33	34	74	34	24	71	10	29	22	48
Washington														
Rep 1	48	23	48	25	52	10	30	61	29	48	32	52	4	12
Rep 2	76	32	42	44	58	1	3	76	32	42	44	58	1	3
Rep mean	66	28	42	38	58	5	15	69	30	43	39	57	3	9
Bethany														
Rep 1	3	3	100	0	0	64	96	16	15	94	1	6	52	78
Rep 2	2	1	50	1	50	66	99	18	15	83	3	17	52	78
Rep mean	3	3	100	0	0	65	96	10	10	100	0	0	58	85
Atlantic														
Rep 1	71	27	38	44	62	3	10	74	27	36	47	64	3	10
Rep 2	58	26	45	32	55	3	10	65	27	42	38	58	2	7
Rep mean	65	28	43	37	57	2	7	68	28	41	40	59	2	7
Average														
Individual rep	38	18	48	20	52	26	59	48	24	51	24	49	20	45
Rep mean	38	18	47	20	53	27	60	45	23	51	22	49	21	48

† None = (no. of lines selected without error ÷ no. of lines selected) x 100.
‡ Acceptance = (no. of lines incorrectly accepted ÷ no. of lines selected) x 100.
§ Rejection = [no. of lines incorrectly rejected ÷ (no. of lines selected without error + no. of lines incorrectly rejected)] x 100.

Table F10. Selection for ≤ 35 g kg^{-1} linolenate content by the family and line methods in population AX11063 at four environments in 1996.

Environment	Family method							Line method						
	Lines selected	Error						Lines selected	Error					
		None†		Acceptance‡		Rejection§			None†		Acceptance‡		Rejection§	
	no.	no.	%	no.	%	no.	%	no.	no.	%	no.	%	no.	%
Ames														
Rep 1	60	58	97	2	3	17	23	64	62	97	2	3	13	17
Rep 2	56	54	96	2	4	21	28	65	63	97	2	3	12	16
Rep mean	56	55	98	1	2	20	27	63	62	98	1	2	13	17
Washington														
Rep 1	72	68	94	4	6	5	7	76	71	93	5	7	2	3
Rep 2	69	66	96	3	4	7	10	75	70	93	5	7	3	4
Rep mean	73	66	90	7	10	6	8	76	69	91	7	9	3	4
Bethany														
Rep 1	19	19	100	0	0	60	76	32	32	100	0	0	47	59
Rep 2	15	15	100	0	0	64	81	35	35	100	0	0	44	56
Rep mean	17	17	100	0	0	61	78	25	25	100	0	0	53	68
Atlantic														
Rep 1	77	61	79	16	21	3	5	77	61	79	16	21	3	5
Rep 2	76	61	80	15	20	3	5	78	62	79	16	21	2	3
Rep mean	80	64	80	16	20	0	0	80	64	80	16	20	0	0
Average														
Individual rep	56	50	91	5	9	23	31	63	57	91	6	9	16	22
Rep mean	57	51	89	6	11	22	30	61	55	90	6	10	17	24

† None = (no. of lines selected without error ÷ no. of lines selected) x 100.
‡ Acceptance = (no. of lines incorrectly accepted ÷ no. of lines selected) x 100.
§ Rejection = [no. of lines incorrectly rejected ÷ (no. of lines selected without error + no. of lines incorrectly rejected)] x 100.

Table F11. Selection for ≤ 35 g kg^{-1} linolenate content by the family and line methods in population AX11080 at four environments in 1996.

Environment	Family method							Line method						
	Lines selected	Error						Lines selected	Error					
		None†		Acceptance‡		Rejection§			None†		Acceptance‡		Rejection§	
	no.	no.	%	no.	%	no.	%	no.	no.	%	no.	%	no.	%
Ames														
Rep 1	48	37	77	11	23	13	26	58	43	74	15	26	7	14
Rep 2	46	37	80	9	20	13	26	55	43	78	12	22	7	14
Rep mean	44	38	86	6	14	12	24	49	41	84	8	16	9	18
Washington														
Rep 1	43	35	81	8	19	15	30	51	37	73	14	27	13	26
Rep 2	56	41	73	15	27	9	18	62	45	73	17	27	5	10
Rep mean	52	39	75	13	25	11	22	55	41	75	14	25	9	18
Bethany														
Rep 1	9	8	89	1	11	56	88	19	17	89	2	11	47	73
Rep 2	3	3	100	0	0	62	95	21	19	90	2	10	46	71
Rep mean	5	5	100	0	0	63	93	14	14	100	0	0	54	79
Atlantic														
Rep 1	69	41	59	28	41	3	7	73	42	58	31	42	2	5
Rep 2	73	42	58	31	42	2	5	75	42	56	33	44	2	5
Rep mean	75	43	57	32	43	1	2	77	43	56	34	44	1	2
Average														
Individual rep	43	31	70	13	30	22	41	52	36	70	16	30	16	31
Rep mean	44	31	71	13	29	22	41	49	35	71	14	29	18	34

† None = (no. of lines selected without error ÷ no. of lines selected) x 100.
‡ Acceptance = (no. of lines incorrectly accepted ÷ no. of lines selected) x 100.
§ Rejection = [no. of lines incorrectly rejected ÷ (no. of lines selected without error + no. of lines incorrectly rejected)] x 100.

Table F12. Selection for ≤ 35 g kg^{-1} linolenate content by the family and line methods in population AX11104 at four environments in 1996.

Environment	Family method							Line method						
	Lines selected	Error						Lines selected	Error					
		None†		Acceptance‡		Rejection§			None†		Acceptance‡		Rejection§	
	no.	no.	%	no.	%	no.	%	no.	no.	%	no.	%	no.	%
Ames														
Rep 1	33	29	88	4	12	16	36	42	36	86	6	14	9	20
Rep 2	29	24	83	5	17	21	47	43	34	79	9	21	11	24
Rep mean	31	27	87	4	13	18	40	37	33	89	4	11	12	27
Washington														
Rep 1	27	25	93	2	7	21	46	42	34	81	8	19	12	26
Rep 2	42	36	86	6	14	10	22	48	40	83	8	17	6	13
Rep mean	36	32	89	4	11	14	30	44	36	82	8	18	10	22
Bethany														
Rep 1	14	13	93	1	7	43	77	23	22	96	1	4	34	61
Rep 2	16	14	88	2	13	41	75	29	27	93	2	7	28	51
Rep mean	16	14	88	2	13	41	75	25	23	92	2	8	32	58
Atlantic														
Rep 1	60	35	58	25	42	2	5	64	37	58	27	42	0	0
Rep 2	59	34	58	25	42	3	8	63	35	56	28	44	2	5
Rep mean	61	35	57	26	43	2	5	63	36	57	27	43	1	3
Average														
Individual rep	35	26	75	9	25	20	43	44	33	75	11	25	13	28
Rep mean	36	27	75	9	25	19	41	42	32	76	10	24	14	30

† None = (no. of lines selected without error ÷ no. of lines selected) x 100.
‡ Acceptance = (no. of lines incorrectly accepted ÷ no. of lines selected) x 100.
§ Rejection = [no. of lines incorrectly rejected ÷ (no. of lines selected without error + no. of lines incorrectly rejected)] x 100.

Table F13. Selection for ≤ 70 g kg^{-1} saturates content and ≤ 35 g kg^{-1} linolenate content by the family and line methods in population AX11056 at four environments in 1996.

Environment	Family method							Line method						
	Lines selected	Error						Lines selected	Error					
		None†		Acceptance‡		Rejection§			None†		Acceptance‡		Rejection§	
	no.	no.	%	no.	%	no.	%	no.	no.	%	no.	%	no.	%
Ames														
Rep 1	24	13	54	11	46	14	52	36	18	50	18	50	9	33
Rep 2	15	8	53	7	47	19	70	31	14	45	17	55	13	48
Rep mean	17	8	47	9	53	22	73	33	17	52	16	48	13	43
Washington														
Rep 1	7	3	43	4	57	28	90	19	8	42	11	58	23	74
Rep 2	31	10	3	21	68	21	68	41	13	32	28	68	18	58
Rep mean	20	5	25	15	75	25	83	31	10	32	21	68	20	67
Bethany														
Rep 1	2	2	100	0	0	46	96	8	6	75	2	25	42	88
Rep 2	0	0	0	0	0	48	100	12	9	75	3	25	39	81
Rep mean	2	2	100	0	0	46	96	5	5	100	0	0	43	90
Atlantic														
Rep 1	55	21	38	34	62	3	13	61	21	34	40	66	3	13
Rep 2	42	16	38	26	62	8	33	50	18	36	32	64	6	25
Rep mean	48	19	40	29	60	5	21	52	20	38	32	62	4	17
Average														
Individual rep	22	9	41	13	59	23	72	32	13	41	19	59	19	59
Rep mean	22	9	41	13	59	25	73	30	13	43	17	57	20	61

† None = (no. of lines selected without error ÷ no. of lines selected) x 100.
‡ Acceptance = (no. of lines incorrectly accepted ÷ no. of lines selected) x 100.
§ Rejection = [no. of lines incorrectly rejected ÷ (no. of lines selected without error + no. of lines incorrectly rejected)] x 100.

Table F14. Selection for ≤ 70 g kg^{-1} saturates content and ≤ 35 g kg^{-1} linolenate content by the family and line methods in population AX11063 at four environments in 1996.

Environment	Family method							Line method						
	Lines selected	Error						Lines selected	Error					
		None†		Acceptance‡		Rejection§			None†		Acceptance‡		Rejection§	
	no.	no.	%	no.	%	no.	%	no.	no.	%	no.	%	no.	%
Ames														
Rep 1	30	9	30	21	70	7	44	37	9	24	28	76	7	44
Rep 2	30	8	27	22	73	8	50	37	12	32	25	68	4	25
Rep mean	30	8	27	22	73	8	50	35	10	29	25	71	6	38
Washington														
Rep 1	17	10	59	7	41	19	66	24	14	58	10	42	15	52
Rep 2	2	2	100	0	0	27	93	3	3	100	0	0	26	90
Rep mean	4	3	75	1	25	25	89	8	5	63	3	38	23	82
Bethany														
Rep 1	1	0	0	1	100	28	100	4	2	50	2	50	26	93
Rep 2	0	0	0	0	0	28	100	9	4	44	5	56	24	86
Rep mean	3	0	0	3	100	28	100	5	1	20	4	80	27	96
Atlantic														
Rep 1	46	10	22	36	78	1	9	51	10	20	41	80	1	9
Rep 2	13	4	31	9	69	7	64	29	6	21	23	79	5	45
Rep mean	30	7	23	23	77	4	36	42	9	21	33	79	2	18
Average														
Individual rep	17	5	30	12	70	16	76	24	8	33	17	67	14	63
Rep mean	17	5	30	12	70	16	76	23	6	27	16	73	15	71

† None = (no. of lines selected without error ÷ no. of lines selected) x 100.
‡ Acceptance = (no. of lines incorrectly accepted ÷ no. of lines selected) x 100.
§ Rejection = [no. of lines incorrectly rejected ÷ (no. of lines selected without error + no. of lines incorrectly rejected)] x 100.

Table F15. Selection for ≤ 70 g kg^{-1} saturates content and ≤ 35 g kg^{-1} linolenate content by the family and line methods in population AX11080 at four environments in 1996.

Environment	Family method							Line method						
	Lines selected	Error						Lines selected	Error					
		None†		Acceptance‡		Rejection§			None†		Acceptance‡		Rejection§	
	no.	no.	%	no.	%	no.	%	no.	no.	%	no.	%	no.	%
Ames														
Rep 1	38	23	61	15	39	3	12	44	23	52	21	48	3	12
Rep 2	25	15	60	10	40	11	42	39	20	51	19	49	6	23
Rep mean	32	20	63	12	38	6	23	35	21	60	14	40	5	19
Washington														
Rep 1	11	9	82	2	18	20	69	18	12	67	6	33	17	59
Rep 2	22	11	50	11	50	18	62	39	12	31	27	69	17	59
Rep mean	24	12	50	12	50	17	59	30	13	43	17	57	16	55
Bethany														
Rep 1	3	2	67	1	33	35	95	10	7	70	3	30	30	81
Rep 2	2	1	50	1	50	36	97	18	11	61	7	39	26	70
Rep mean	2	2	100	0	0	6	75	7	6	86	1	14	2	25
Atlantic														
Rep 1	37	18	49	19	51	8	31	38	19	50	19	50	7	27
Rep 2	25	12	48	13	52	15	56	36	15	42	21	58	12	44
Rep mean	31	16	52	15	48	11	41	40	18	45	22	55	9	33
Average														
Individual rep	20	11	57	9	43	18	62	30	15	49	15	51	15	50
Rep mean	22	13	57	10	43	10	44	28	15	52	14	48	8	36

† None = (no. of lines selected without error ÷ no. of lines selected) x 100.
‡ Acceptance = (no. of lines incorrectly accepted ÷ no. of lines selected) x 100.
§ Rejection = [no. of lines incorrectly rejected ÷ (no. of lines selected without error + no. of lines incorrectly rejected)] x 100.

Table F16. Selection for ≤ 70 g kg^{-1} saturates content and ≤ 35 g kg^{-1} linolenate content by the family and line methods in population AX11104 at four environments in 1996.

	Family method							Line method						
	Lines	Error						Lines	Error					
Environment	selected	None†		Acceptance‡		Rejection§		selected	None†		Acceptance‡		Rejection§	
	no.	no.	%	no.	%	no.	%	no.	no.	%	no.	%	no.	%
Ames														
Rep 1	14	6	43	8	57	8	57	31	8	26	23	74	6	43
Rep 2	17	6	35	11	65	8	57	30	11	37	19	63	3	21
Rep mean	14	7	50	7	50	7	50	26	11	42	15	58	3	21
Washington														
Rep 1	6	5	83	1	17	21	81	14	9	64	5	36	17	65
Rep 2	2	1	50	1	50	25	96	15	11	73	4	27	15	58
Rep mean	4	3	75	1	25	23	88	7	5	71	2	29	21	81
Bethany														
Rep 1	4	3	75	1	25	25	89	9	6	67	3	33	22	79
Rep 2	11	6	55	5	45	22	79	20	11	55	9	45	17	61
Rep mean	8	4	50	4	50	24	86	12	6	50	6	50	22	79
Atlantic														
Rep 1	9	3	33	6	67	12	80	24	10	42	14	58	5	33
Rep 2	17	4	24	13	76	11	73	27	9	33	18	67	6	40
Rep mean	12	4	33	8	67	11	73	23	7	30	16	70	8	53
Average														
Individual rep	10	4	40	6	60	17	80	21	9	42	12	56	11	56
Rep mean	10	5	53	5	53	16	76	17	7	41	10	57	14	66

† None = (no. of lines selected without error ÷ no. of lines selected) x 100.
‡ Acceptance = (no. of lines incorrectly accepted ÷ no. of lines selected) x 100.
§ Rejection = [no. of lines incorrectly rejected ÷ (no. of lines selected without error + no. of lines incorrectly rejected)] x 100.

Table F17. Selection for ≥ 87% of the seed yield of the check genotypes by the family and line methods in population AX11056 at four environments in 1996.

Environment	Family method							Line method						
	Lines selected	Error						Lines selected	Error					
		None†		Acceptance‡		Rejection§			None†		Acceptance‡		Rejection§	
	no.	no.	%	no.	%	no.	%	no.	no.	%	no.	%	no.	%
Ames														
Rep 1	40	33	83	7	18	24	42	48	38	79	10	21	19	33
Rep 2	46	34	74	12	26	23	40	57	42	74	15	26	15	26
Rep mean	46	36	78	10	22	21	37	53	42	79	11	21	15	26
Washington														
Rep 1	63	51	81	12	19	8	14	64	51	80	13	20	8	14
Rep 2	20	18	90	2	10	40	69	23	20	87	3	13	38	66
Rep mean	44	37	84	7	16	21	36	50	42	84	8	16	16	28
Bethany														
Rep 1	44	36	82	8	18	20	36	49	39	80	10	20	17	30
Rep 2	47	37	79	10	21	20	35	56	43	77	13	23	14	25
Rep mean	50	40	80	10	20	17	30	53	41	77	12	23	16	28
Atlantic														
Rep 1	51	40	78	11	22	17	30	55	42	76	13	24	15	26
Rep 2	55	44	80	11	20	13	23	58	45	78	13	22	12	21
Rep mean	60	50	83	10	17	7	12	62	50	81	12	19	7	12
Average														
Individual rep	46	37	80	9	20	21	36	51	40	78	11	22	17	30
Rep mean	50	41	82	9	18	17	29	55	44	80	11	20	14	24

† None = (no. of lines selected without error ÷ no. of lines selected) x 100.
‡ Acceptance = (no. of lines incorrectly accepted ÷ no. of lines selected) x 100.
§ Rejection = [no. of lines incorrectly rejected ÷ (no. of lines selected without error + no. of lines incorrectly rejected)] x 100.

Table F18. Selection for ≥ 87% seed yield of the check genotypes by the family and line methods in population AX11063 at four environments in 1996.

Environment	Family method							Line method						
	Lines selected	Error						Lines selected	Error					
		None†		Acceptance‡		Rejection§			None†		Acceptance‡		Rejection§	
	no.	no.	%	no.	%	no.	%	no.	no.	%	no.	%	no.	%
Ames														
Rep 1	70	62	89	8	11	8	11	70	62	89	8	11	8	11
Rep 2	65	59	91	6	9	11	16	66	60	91	6	9	10	14
Rep mean	71	65	92	6	8	5	7	71	65	92	6	8	5	7
Washington														
Rep 1	71	68	96	3	4	4	6	72	69	96	3	4	3	4
Rep 2	36	36	100	0	0	36	50	46	45	98	1	2	27	38
Rep mean	60	59	98	1	2	13	18	61	60	98	1	2	12	17
Bethany														
Rep 1	65	60	92	5	8	10	14	68	63	93	5	7	7	10
Rep 2	64	59	92	5	8	11	16	70	64	91	6	9	6	9
Rep mean	66	61	92	5	8	9	13	69	64	93	5	7	6	9
Atlantic														
Rep 1	47	43	91	4	9	26	38	55	51	93	4	7	18	26
Rep 2	59	54	92	5	8	15	22	62	56	90	6	10	13	19
Rep mean	56	52	93	4	7	17	25	60	55	92	5	8	14	20
Average														
Individual rep	60	55	92	5	8	15	22	64	59	92	5	8	12	16
Rep mean	63	59	94	4	6	11	16	65	61	93	4	7	9	13

† None = (no. of lines selected without error ÷ no. of lines selected) x 100.

‡ Acceptance = (no. of lines incorrectly accepted ÷ no. of lines selected) x 100.

§ Rejection = [no. of lines incorrectly rejected ÷ (no. of lines selected without error + no. of lines incorrectly rejected)] x 100.

Table F19. Selection for ≥ 87% seed yield of the check genotypes by the family and line methods in population AX11080 at four environments in 1996.

Environment	Family method							Line method						
	Lines selected	Error						Lines selected	Error					
		None†		Acceptance‡		Rejection§			None†		Acceptance‡		Rejection§	
	no.	no.	%	no.	%	no.	%	no.	no.	%	no.	%	no.	%
Ames														
Rep 1	21	21	100	0	0	26	55	37	32	86	5	14	15	32
Rep 2	21	17	81	4	19	30	64	32	27	84	5	16	20	43
Rep mean	24	22	92	2	8	26	54	33	28	85	5	15	20	42
Washington														
Rep 1	27	24	89	3	11	21	47	37	33	89	4	11	12	27
Rep 2	37	30	81	7	19	14	32	46	35	76	11	24	9	20
Rep mean	32	28	88	4	13	17	38	42	36	86	6	14	9	20
Bethany														
Rep 1	39	30	77	9	23	14	32	46	35	76	11	24	9	20
Rep 2	38	25	66	13	34	18	42	50	36	72	14	28	7	16
Rep mean	39	30	77	9	23	13	30	47	35	74	12	26	8	19
Atlantic														
Rep 1	33	29	88	4	12	18	38	41	32	78	9	22	15	32
Rep 2	21	18	86	3	14	29	62	37	30	81	7	19	17	36
Rep mean	33	29	88	4	12	18	38	40	33	83	7	18	14	30
Average														
Individual rep	30	24	82	5	18	21	47	41	33	81	8	20	13	28
Rep mean	32	27	85	5	15	19	41	41	33	80	8	20	13	28

† None = (no. of lines selected without error ÷ no. of lines selected) x 100.
‡ Acceptance = (no. of lines incorrectly accepted ÷ no. of lines selected) x 100.
§ Rejection = [no. of lines incorrectly rejected ÷ (no. of lines selected without error + no. of lines incorrectly rejected)] x 100.

Table F20. Selection for ≥ 87% seed yield of the check genotypes by the family and line methods in population AX11104 at four environments in 1996.

Environment	Family method							Line method						
	Lines selected	Error						Lines selected	Error					
		None†		Acceptance‡		Rejection§			None†		Acceptance‡		Rejection§	
	no.	no.	%	no.	%	no.	%	no.	no.	%	no.	%	no.	%
Ames														
Rep 1	24	11	46	13	54	27	71	36	20	56	16	44	18	47
Rep 2	27	19	70	8	30	19	50	41	27	66	14	34	11	29
Rep mean	24	14	58	10	42	24	63	37	25	68	12	32	13	34
Washington														
Rep 1	23	19	83	4	17	19	50	35	28	80	7	20	10	26
Rep 2	29	24	83	5	17	15	38	40	31	78	9	23	8	21
Rep mean	24	19	79	5	21	19	50	38	30	79	8	21	8	21
Bethany														
Rep 1	31	25	81	6	19	19	43	42	35	83	7	17	8	19
Rep 2	14	14	100	0	0	30	68	28	26	93	2	7	18	41
Rep mean	20	19	95	1	5	25	57	33	31	94	2	6	13	30
Atlantic														
Rep 1	46	29	63	17	37	8	22	53	32	60	21	40	5	14
Rep 2	26	16	62	10	38	21	57	46	28	61	18	39	9	24
Rep mean	35	23	66	12	34	14	38	46	29	63	17	37	8	22
Average														
Individual rep	28	20	71	8	29	20	50	40	28	71	12	29	11	28
Rep mean	26	19	73	7	27	21	52	39	29	75	10	25	11	27

† None = (no. of lines selected without error ÷ no. of lines selected) x 100.

‡ Acceptance = (no. of lines incorrectly accepted ÷ no. of lines selected) x 100.

§ Rejection = [no. of lines incorrectly rejected ÷ (no. of lines selected without error + no. of lines incorrectly rejected)] x 100.

APPENDIX G: SELECTION INTENSITY FOR SEED YIELD FOR INDIVIDUAL REPLICATIONS AND REPLICATION MEANS.

Table G1. Selection intensity required at Ames to retain the 10 lines with the highest mean seed yield at Washington, Atlantic, and Bethany.

	AX11056			AX11063			AX11080			AX11104			Means	
Lines retained†	Rep 1	Rep 2	Both	Rep 1	Rep 2	Both	Rep 1	Rep 2	Both	Rep 1	Rep 2	Both	Individual reps	Both reps
	%													
1/1	25	86	2	11	25	22	2	1	5	10	20	5	23	9
1/10	2	1	2	1	4	2	1	1	1	1	1	2	2	2
2/10	4	2	5	5	7	5	2	2	2	4	2	5	4	4
3/10	10	4	14	7	10	6	10	4	5	6	4	7	7	8
4/10	14	5	19	10	13	10	12	8	6	10	8	10	10	11
5/10	25	29	20	11	18	12	16	16	12	14	11	12	18	14
6/10	36	32	24	17	22	13	25	20	18	17	19	14	24	17
7/10	40	35	26	37	25	16	29	24	40	25	20	34	29	29
8/10	41	59	43	40	35	22	31	50	41	31	24	43	39	37
9/10	44	60	44	52	40	49	34	53	48	46	68	47	50	47
10/10	71	86	59	73	42	62	67	76	52	88	97	54	75	57

† 1/1 = Highest yielding line; No./10 = Number of the 10 highest yielding lines selected.

Table G2. Selection intensity required at Washington to retain the 10 lines with the highest mean seed yield at Ames, Atlantic, and Bethany.

	AX11056			AX11063			AX11080			AX11104			Means	
Lines retained†	Rep 1	Rep 2	Both	Rep 1	Rep 2	Both	Rep 1	Rep 2	Both	Rep 1	Rep 2	Both	Individual reps	Both reps
	%													
1/1	5	61	65	13	1	18	6	1	1	58	47	40	24	31
1/10	1	6	4	6	1	1	6	1	1	1	5	5	3	3
2/10	2	7	6	10	5	4	7	2	2	4	12	10	6	6
3/10	4	11	8	13	6	6	13	6	6	11	14	11	10	8
4/10	5	13	10	16	8	11	14	7	7	14	16	13	12	10
5/10	8	20	11	19	14	12	22	11	12	17	18	17	16	13
6/10	28	22	12	31	29	14	25	16	19	20	24	29	24	19
7/10	29	23	20	34	35	18	37	18	32	32	30	34	30	26
8/10	32	29	22	47	36	19	43	37	46	40	37	40	38	32
9/10	60	54	34	52	52	24	64	49	50	43	40	62	52	43
10/10	86	61	65	65	72	83	73	80	52	58	47	74	68	69

† 1/1 = Highest yielding line; No./10 = Number of the 10 highest yielding lines selected.

Table G3. Selection intensity required at Bethany to retain the 10 lines with the highest mean seed yield at Ames, Washington, and Atlantic.

	AX11056			AX11063			AX11080			AX11104			Means	
Lines retained†	Rep 1	Rep 2	Both	Rep 1	Rep 2	Both	Rep 1	Rep 2	Both	Rep 1	Rep 2	Both	Individual reps	Both reps
	%													
1/1	12	47	32	8	41	31	1	13	1	16	17	4	19	17
1/10	5	2	10	5	5	4	1	1	1	1	2	4	3	5
2/10	11	5	19	8	8	6	2	2	4	5	4	7	6	9
3/10	12	17	29	18	10	10	4	8	5	6	11	11	11	14
4/10	14	22	32	19	14	13	5	11	6	16	17	16	15	17
5/10	25	31	47	24	18	30	10	13	7	18	19	29	20	28
6/10	31	34	53	29	31	31	13	16	10	19	20	30	24	31
7/10	54	37	56	31	40	43	17	20	14	29	26	44	32	39
8/10	58	44	68	32	41	44	24	35	20	40	37	49	39	45
9/10	62	47	83	35	54	49	73	48	34	44	38	52	50	55
10/10	64	61	86	46	56	64	76	54	50	58	66	53	60	63

† 1/1 = Highest yielding line; No./10 = Number of the 10 highest yielding lines selected.

Table G4. Selection intensity required at Atlantic to retain the 10 lines with the highest mean seed yield at Ames, Washington, and Bethany.

	AX11056			AX11063			AX11080			AX11104			Means	
Lines retained†	Rep 1	Rep 2	Both	Rep 1	Rep 2	Both	Rep 1	Rep 2	Both	Rep 1	Rep 2	Both	Individual reps	Both reps
	%													
1/1	38	7	28	5	12	38	1	2	1	2	19	7	11	19
1/10	13	1	4	2	4	1	1	1	1	1	2	1	3	2
2/10	23	4	11	5	6	2	5	2	4	2	8	4	7	5
3/10	24	5	14	8	8	6	10	5	6	4	19	7	10	8
4/10	31	7	23	12	12	10	11	7	7	14	22	14	15	14
5/10	37	40	28	22	18	11	16	14	11	22	26	16	24	17
6/10	38	42	34	23	24	13	22	17	17	24	32	19	28	21
7/10	49	48	36	24	29	16	32	19	34	61	34	23	37	27
8/10	56	58	38	29	30	38	34	31	47	80	43	25	45	37
9/10	71	62	50	30	34	44	49	35	48	83	72	26	55	42
10/10	78	86	80	36	62	85	72	96	52	85	90	50	76	67

† 1/1 = Highest yielding line; No./10 = Number of the 10 highest yielding lines selected.

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